k03251

INDEX

Chatfield, C., 82
Cheese and butter, importance, 17
Chickens, importance, 8, 16
Chocolate, 58
Christians, W. F., 83
Citrus fruit, recent expansion, 57
Clark, C., 82
Clothing, low priority, 1
Consumption, amount daily, 15
  cost of living studies, 13, 14
    compared with production studies, 13
    grain, plant and animal, 13
  effect of income, 17
  importance, of various foods, 16
    various parts of plant, 16
  per capita, 11
  production studies, 11, 12, 13
    animal, 13
    grains and plant, 13, 14, 15
  purposes, 14
  varies with climate, size, etc , 12, 15
Corn, hybrid, effect on yields, 58
  importance, 6, 7, 11
  spread over the world, 57
  trade, 11
Cost of living studies, compared with food production, 13
Cows, discarded dairy, source of beef,

Crawford, W., 82
Cushing, S. W., 82

Danger spot, Europe not Asia, 75
Davis, D H , 82
De Candolle, A., 82
Deficit and surplus areas, 74
DeGraff, H. F., preface
Deltas, size of, 13
Deserts, fertility of, 45
Diseases, plants and animals, 61
Double cropping, extensive in Asia, 59
Down-trodden third, ways to help, 70
Drainage, costs, 30
  importance, possibilities, 31
Drained land, source of food, 31
Dykes, Holland, 30

Earth, age of, 37
  size of, 37
Earth's crust, how changed, 38
  soil, 42
  surface, thickness of, 42
East, E. M., 82
Education, low priority, 1
Eggs, amount consumed, 15
  importance, 6
Equality not established by peaceful methods, 76
Equalization, food, 69, 70
Erosion, alters land forms, 38
  beneficial and harmful, 38
  defined, 26
Eskimo, food consumption, 12
Evaporation, effect of temperature, 25
Experiment stations, expansion of, 77
Exports, 10, 77

Famines, none when livestock abundant, 73
Feed for livestock, grain, 8
Fertilizer, commercial, 52, 54
Finch, V C., 82, 83
Fish, amount consumed, 15
  areas, 63, 64
  importance, 5
  live on plants, 63
Floodplains, 13
Fruit, amount consumed, 15
  and vegetables, production, trade, 5, 11
Fuente, E., 83

Goats, importance, 8
Goode, J P., 82
Grain, acres per person, 68
  amount consumed, 15
  amount fed, 8, 9
  importance, 6
  production, 5, 68
  see Seeds, mature
  trade, most of, 11
Grimm, alfalfa, 58

Hannay, A. M., 82
Hartwig, H. B., preface

Heat, artificial, cost, 31
  from sun, 31, 32
  necessary for growth, 31
High cost of living, 77
Hill lands, described, 39
Hills, area, 41
Hitler, 76, 77
Horse *vs.* mechanical power, 56
Housing, low priority, 1
Huntington, E., 82

Ill-fed third, 2
Immigration, possibilities, 49, 50
  restrictions, 77
  to agricultural areas slowing down, 49
  to New World, 2
Imports, food, Europe largest, 10
Income, effect on consumption, 17
Indian Year Book, 82
International Institute of Agriculture, 82
Irrigation, area, 28
  costs, 29, 30
  Himalayas, 29
  important, 31
  most in Asia, 28, 29
  no shortage land, 28
  possibilities, 28
  shortage of water, 29
  source of food, 31
  United States, 29
Israelsen, O. W., 82
Iturraspe, J. E., 83

Juices, amount consumed, 15

Kaiser, 77
Kendrew, W. G., 82
Klages, K. H. W., 82

Labor, effect of larger amounts on production, 55
Land forms, best distribution in Europe, 41
  defined, 37
  unevenly distributed, 41
Lawrence in Arabia, 16
Lay of the land, importance, 22
  rain, 24
Leaching, defined, 26
  in grasslands, 45
  in tropics, 34
League of Nations, 82
Leaves, importance, 6
Lebensraum, 76, 78
Light, absorption of carbon dioxide, 35
  artificial, cost, 31
  does not limit food production, 35
  necessary for growth, 31
Livestock, a shock absorber, 73
  breeding for appearance, 60
  improvement slow, 60
Loess soils, wind-carried, 40, 41
Lyon, T. L., 83

Machinery, effect on production, 56, 57
  replaces horses, increases food, 56
Malthus, 2
Manure, animal, 52
  animal more important than human, 53
  green manure crops, 52, 54, 55
  human, 52
  human, increased use, 53
Meat, amount consumed, 15
  importance, 6
  production, 5
Mendel's law, 58
Migone, R. C., 83
Milk, amount consumed, 15
  amount produced, 5
  possibilities of expansion, 71
  produced everywhere, 7
  production on glacial plains, 41
  quart a day, 71
  related to pastures, 7
  uses, 16
Miller, E. C., 83
Moisture, *see* Water; Rainfall
Mordoff, R. A., preface
Morimoto, K., 83
Mountains, and rains, 24
  area, 41
  described, 39

Mountains *(continued)*
  height, 37
Mussolini, Benito, 30

National Industrial Conference Board, 83
Nebuchadnezzar, 58
Nitrogen, 54

Oats, importance, 7
Ocean, depth of, 37
Oil seeds, importance, 7
Okies, 26
Olcott, M. T., 83
Organic matter, importance, 43

Paarlberg, D., preface
Penck, A., 49, 83
Philip, G., 83
Phosphate, 54
Photosynthesis, 20, 21
  and supply of carbon dioxide, 36
  inefficient, 35
Pigs, importance, 16
Plains, area, 41
  glacial, dairy production, 41
  importance, 39
  types of, 39
Planners and plans, no shortage, 17, 71
Plant, breeding, effects, 58
  foods, consumption, 13, 15
    importance, 6
    production and trade, 10
  growth, critical period, 26
  life of water, 63
  needs of, 21
Plateaus, area, 41
  defined, 38
Platt, F. L., preface
Polar regions, little rain or snow, 24
Pontine marshes, 30
Population, continental, 68
  control, 71
  danger spots, 75
  density, 67
  excess from Europe, 76
  irrigated crops, 28, 29
  possible expansion, 68, 69
  pressure, and war, 76
  pressure on food supply, 2, 8, 67
  response to food, 2
  supported at various continental standards, 69
Pork, importance, 8
Potatoes, world-wide, 57
Poultry, importance, 8
Priority, food *vs.* clothing, education, housing, 1
Production, amount, 5
  effect of fertilizer, 52, 55
  effect of labor, 55
  effect of machinery, 55, 56
  increasing acreage and yields, 19
  increasing on present acreage, 51
  plant, animal, 7
  proportion of continents adapted to food, 50

Rain and mountains, 24
Rainfall, adequate and inadequate, 26
  area with adequate, 48
  area with adequate, combined with other factors, 48
  area with reliable, 48
  area with reliable, combined with other factors, 48
  ideal, 26
  nature's free work, 24
  on earth's surface, 26
  seasonal needs, 26
Rationing food, 70
Redistribution of surplus food, 2
Regimentation leads to nationalism, 79
Religion influenced by food, 1
Rice, double and triple cropping, 59
  importance, 6, 7, 11
  polished, 15, 16
  trade, 11
Rocks and plant food, 21
Roots, importance, 6, 15
Run-off, effect of climate, 25
Rye, 7, 15

Sap, importance, 6, 15
Schloemer, F. C., 81

- Scoville, G. P., preface
- Scudder, M., preface
- Sea, food from, 63
  - yields low, 64, 65
- Seeds, immature, importance, 6
  - mature, most of food, 6, 15
- Sheep, importance, 8, 16
  - parts eaten, 16
- Shortage, food, 2
  - likely to continue, 79
- Social uplifters, 17
- Soils, area with fertile, 46, 48
  - area with fertile, combined with other factors, 48
  - complex, 46
  - forest, importance, 45
  - formation of, 42, 44
  - functions, three, 46
  - insignificant, but most important part of earth, 42
  - moved by water, 43
  - organic matter, 43
  - podzol, importance, 46
  - quality difficult to measure, 46
  - tropical, leached, 49
  - tundra, importance, 45
  - types, 44
  - weathering, 42
- Soybeans, expansion recent, 58
  - pressed for oil, 16
- Spoehr, H. A., 83
- Standard of living, adjustment in Europe, 79
  - and population, 68, 69
  - Europe dependent on trade, 76
  - high in Europe, 12
  - ways to improve, 70
- Starvation, 2, 12, 74
- Stems, importance, 6, 15
- Strawberry, 58
- Struggle for existence, 1
- Sugar, amount consumed, 15
  - beets, 16
  - beets, improved varieties, 57
  - cane, 15, 16
  - produced everywhere, 7
  - production, 5
  - trade, 11
- Sun, rays and atmospheric blanket, 32
  - size of, 31
  - source of heat and light, 31
- Sunlight, area with adequate, 48
  - area with adequate, combined with other factors, 48
  - required, 21

- Taylor, G., 83
- Temperature, area with favorable, 34, 48
  - area with favorable, combined with other factors, 48
  - causes of variation, 32, 33, 34
  - effect on evaporation, 25
  - effect on moisture in air, 23
  - three belts, 34
- Thompson, W. S., 83
- Tomato, once thought poisonous, 57
- Topography, area with favorable, 48
  - area with favorable, combined with other factors, 48
  - favorable, 42
  - *see* Land forms, Plains, etc
- Trade, between continents, 9
  - between countries, 9
  - grain most important, 11
  - importance to Europe, 79
  - within countries, 9
- Trewartha, G. T., 82
- Tropics, leached soils, 34
  - much rain, 24
- Tung, S. T., 83

- United States Department of Agriculture, 83
- Upgrading food habits, 17

- Van Loon, H. W., 83
- Van Royen, W., 81
- Van Valkenburg, S., 82
- Varieties, new, 57
- Vegetables, amount consumed, 15
  - and fruits, production and trade, 5, 7, 11

- War, cause of, 76
  - effect on food supplies, 74

War (*continued*)
  frequency, 76
  luxury for rich, 75
Wartime food problems, 72
Water, amount needed, 25, 26
  content of foods, 11, 12
  covers three-fourths of earth, 63
  food from, 63
  loss through evaporation, run-off, drainage, 25
  necessary for growth, 21, 25
  present everywhere, 22
  transports soil, 43
Weir, W. W., 83
Wheat, basic food, 15
  importance, 6, 7, 11
  milled, 16
  trade, 11
Whitback, R. H., 83
Williams, F. E., 82, 83
Wind, monsoon, 24
  moves soil, 43, 44
  transports water, 23
Woodbury, R. M., 83
Wright, Q., 83

Yields, effect of hybrid corn, 58
  per acre, 51

Chapter I

Introduction

DOWN through history food has been man's most important problem. Clothing, housing, education, and amusement have always had a lower priority rating than food. Man's history has always been a race between food supplies and the number of mouths to be fed. In this respect man's existence is like that of other forms of life. The fishes struggle for the meager food supplies of the oceans. Plants struggle against the elements—poor soil and too much or too little rainfall—and against other plants. The plant-consuming animals contend for their meager supplies. If there is an abundance of plants, the numbers of rabbits, zebras, giraffes, and buffaloes increase rapidly. The carnivorous animals also have a continuous struggle for existence. America's wolves and panthers, Africa's lions, and Asia's tigers multiply until they reach the limit of their food supply. Man, whether he lives on meat or plant food, finds the struggle equally difficult. Like other animals, he multiplies quickly whenever his food supply is increased.

The difficulty of obtaining food has influenced man's religious views. Frequently he has included in his concept of the hereafter those scarcities which most plagued his existence or blocked his aspirations while on earth. Early biblical history records the giving of meat animals as a sacrifice to the Deity. At different times and places it has been the custom to place food in or on graves; the modern well-fed American has substituted flowers.

The American Indian had for his hereafter a "happy hunting ground" where there was an abundance of easily caught game.

Toward the end of the eighteenth century Malthus observed this struggle between population and food supply and set it down as a "law" of nature. Briefly, the law states that man tends to multiply more rapidly than his food supply increases. So long as this law operates man is almost continuously on the verge of starvation. The current ideas of great world surpluses contradict the laws of nature, the history of mankind, and the realism of Malthus.

Although most of man's existence has been blighted with food shortages, there have been occasional periods when there was a relative abundance of food in some regions. Soon after the western hemisphere was opened up, immigrants flowed to North and South America and relieved somewhat the pressure of population on the European food supply. These immigrants produced increasing amounts of food and had a sharp rise in their standard of living even though the population expanded rapidly. For about a century, half the world had what might be called a relative abundance of food. Man ate well, ate white bread instead of black, and ate increasing amounts of animal products.

About 1900 this period of relative abundance began to draw to a close. The population was increasing faster than food supplies, and the consumption of the highly prized meats was decreasing. A world-wide campaign was initiated to make two blades of grass grow where one grew before. This period of scarcity was temporarily arrested by World War I, which reduced the number of European consumers with no diminution of food production.

During the late twenties and early thirties food prices declined with the world-wide collapse in all prices. Europe, the Americas, and Oceania planned to reduce food production, dispose of "surpluses," and the like. Despite this great "abundance," the undernourished and ill-fed third were discovered. The politicians, nutritionists, and economists did an unusually effective job of convincing the people of Europe and the New World that food habits should be upgraded. Just how continued food surpluses and an undernourished third existed side by side for two decades has not been explained.

It is in just such an environment of muddled thinking that many find themselves today. Some believe that the possibilities of expanding food production are practically unlimited and must be controlled, whereas others believe that little opportunity exists for much expansion. Some believe that the average diet of the world could be greatly improved by the wise use or redistribution of accumulated "surpluses." Others believe that there are no surpluses, that the accumulated stocks would not feed the world for long, that little food is wasted, and that redistribution would be blocked by consumers in the contributing nations.

In view of this confusion and difference of opinion, an attempt will be made to present some facts about the food habits of the world's two billion people, about the differing degrees of pressure on food supplies, about the production of food and the prospects for its increase, and about the possibilities of upgrading food habits.

Chapter 2

Production, Trade, and Consumption

PRODUCTION

ANNUALLY the world produces about 3,686 billion pounds of food products, exclusive of forage crops and pasture (table 1). Plant foods represent about 85 per cent of this total, whereas the production of animal products is relatively small, 563 billion pounds.

The various plant and animal products differ widely in their moisture content. On the average they are about half water.

TABLE 1. APPROXIMATE WORLD FOOD PRODUCTION *

KIND OF FOOD	BILLION POUNDS		PER CENT	
	Wet	Dry	Wet	Dry
Grains †	1,676	1,508	45.5	82.4
Vegetables and fruits ‡	1,376	137	37.3	7.5
Sugar	71	71	1.9	3.9
Milk	422	55	11.5	3.0
Meat §	102	50	2.8	2.7
Fish	23	5	0.6	0.3
Eggs	16	4	0.4	0.2
TOTAL	3,686	1,830	100.0	100.0

* Not all this food was consumed by human beings. About 40 per cent of the grain was fed to livestock and used for seed.

† The term *grains* as used here includes the cereals, oil-bearing seeds, beans, peas, peanuts, etc.

‡ Potatoes and cassava or manioca were included with the vegetables and fruits.

§ Poultry was included with the meat.

On a dry basis the world's food production is 1,830 billion pounds. Plant foods represent 94 per cent of this total, and the highly prized animal foods only 6 per cent. Grains, the mature seeds of plants, represent four-fifths of the total and are by all odds the most important part of world food production. The leaves, stems, saps, roots, and immature seeds of plants represent about one-tenth. Of the highly prized foods, milk and meat are over ten times as important as fish and eggs.

Asia and Europe produce about two-thirds of the world's food (table 2). These two continents and North America produce almost nine-tenths of the world's food. Africa, South America, and Oceania produce only 12 per cent, although their land surface is nearly as large as that of Asia, Europe, and North America.

TABLE 2. APPROXIMATE CONTINENTAL FOOD PRODUCTION

CONTINENT	BILLION POUNDS		PER CENT
	Wet	Dry	Dry
Asia	1,522	727	40
Europe	1,137	519	28
North America	599	364	20
Africa	210	102	6
South America	177	97	5
Oceania	41	21	1
WORLD	3,686	1,830	100

Asia is the world's greatest food producer, but animal products are only a small part of her food. She produces 41 per cent of the world's plant foods, which is about equal to the production of Europe and North America combined (table 3). On the other hand, Asia produces only one-sixth of the world's meat, dairy, and poultry products, whereas Europe and North America produce almost three-fourths.

Grains represent over 80 per cent of the world's food production, on a dry basis. Wheat, corn, and rice in that order are the most important grain crops and represent about half of the world's grain production. Oats, rye, barley, and oil-bearing seeds are next in importance and account for over one-fourth.

Wheat ranks first or second in importance on each of the six continents. North America produces the largest part of the world's corn crop, although corn is grown in most other sections of the world. The bulk of the world's rice and oil seeds is produced in Asia. Oats are raised mainly in the cool parts of Europe and North America. Rye is largely confined to the sandy and poorer soils of northern Europe. Vegetables are produced everywhere.

TABLE 3. APPROXIMATE CONTINENTAL PRODUCTION OF PLANT AND ANIMAL FOODS—Dry Basis

CONTINENT	BILLION POUNDS		PER CENT	
	Plant	Animal	Plant	Animal
Asia	709	18	41	16
Europe	466	53	27	47
North America	337	27	20	24
Africa	98	3	6	3
South America	89	9	5	8
Oceania	18	3	1	2
WORLD	1,717	113	100	100

Sugar, like wheat, is produced on all continents. Most of the sugar beets are raised in Europe, and most of the sugar cane on a few islands around Asia and North America[1] that have the special climatic conditions necessary for efficient production.

Milk is produced everywhere, but most of it is produced in the cooler parts of Europe and North America where there is an abundance of hay and pasture.

Beef, the most important meat, is produced everywhere, but production is greatest in Europe and North and South America. Although cattlemen take pleasure in their jokes about "dairy beef," milk and beef production are usually closely associated. Discarded dairy cows may not produce the juiciest steaks, but they are an important source of beef. In fact, most of the world's "beef" is old, worn-out bullocks, oxen, beef and dairy cows,

---

[1] India and Brazil are the largest continental producers.

camels, and horses. The animals known as "beef cattle" are produced in almost every country. Except for those raised on the lush pastures of Argentina, however, most of them range over pastures that are not good enough for milk cows.

The production of pork, which ranks next to beef in importance, is also greatest in Europe and North America. North American pork is produced largely from the corn crop. Europe's pork is produced from a variety of low-grade grains, root crops, whey, and skim milk. In most of the rest of the world pigs are raised as scavengers.

All over the world sheep, goats, yaks, and the like browse over pastures too poor to maintain cattle. They are an unimportant source of meat to all except the nomads and others who live on the poorer parts of the earth. Asia, Australia, and Africa, with huge amounts of poor land, produce more lamb and mutton in proportion to other meats than do the other three continents, Europe and the Americas.

Chickens and other classes of poultry comprise only a small part of the world's food. They are widely scattered and most of them are scavengers.

FEED AND SEED

About 40 per cent of the world's grain is used as seed or is fed to livestock. Part is fed as grain and part as a wide variety of by-products, such as wheat bran, corn gluten, etc. North America feeds a larger proportion of its grain to livestock than any other continent; Europe is a close second (table 4). On these continents feed and seed together represent 75 and 61 per cent of the production, respectively. Europe and North America produce less than half the world's grain but feed over 80 per cent of that fed to the world's livestock.

Asia, the world's greatest grain producer, diverts only 14 per cent of its production to feed and seed. Human beings are so numerous there, in proportion to the amount of grain, that they eat most of it and use a minimum as food for livestock.

TABLE 4. APPROXIMATION OF GRAIN USED FOR FEED AND SEED—Wet Basis

CONTINENT	BILLIONS OF POUNDS		PER CENT
	Production	Feed and seed	Feed and seed
Asia	683	98	14
Europe	453	276	61
North America	342	255	75
Africa	95	12	13
South America	86	29	34
Oceania	17	7	41
WORLD	1,676	677	40

TRADE

An enormous amount of food moves within countries, a much smaller amount from one nation to another on a given continent, and only a small quantity from continent to continent. The bulky citrus fruits and vegetables from California, Florida, and Texas are carried thousands of miles to northeastern United States. Kansas' wheat, Iowa's hogs, and Wisconsin's cheese are transported long distances within the United States. Relatively little food, however, moves either in international trade among the nations of North America or in intercontinental trade.

In Asia, on the other hand, food is seldom moved long distances, even within her countries. This is due to the fact that a high percentage of the people are farmers, most of whom produce only enough food for their own subsistence and a little for the local officials and tradesmen. Asia, also, has little international or intercontinental trade in food.

Of all the continents, Europe has the largest volume of trade among continents, the largest volume of trade among its nations, and the largest volume of trade within the countries.

Only a small part of world food production, about 67 billion pounds or six per cent, enters into intercontinental trade (table 5). Asia, the largest producer of food, exports only two per cent of her production. Oceania, the smallest producer, exports the largest proportion. Exports are much more important to South America and Oceania than they are to the other continents.

Table 5. APPROXIMATE PRODUCTION AND INTERCONTINENTAL TRADE—Dry Basis

CONTINENT	BILLI Production *	Trade	Trade
Asia	639	12 exported	2
Europe	271	67 imported	25
North America	123	18 exported	15
Africa	91	6 exported	7
South America	71	22 exported	31
Oceania	15	9 exported	60
WORLD	1,210	67 exported and imported	6

* Less feed and seed.

Of the six continents, only Europe has an excess of imports over exports. She imports 67 billion pounds, which is 25 per cent of her production. About one-fourth of this imported food comes from North America, a third from South America, and two-fifths from Asia, Oceania, and Africa.

Animal products are a small proportion of the world's food production, and an even smaller proportion of the world's trade, six and four per cent respectively (table 6). Stated another way, only about two per cent of the world's food from animal sources

Table 6. APPROXIMATE PRODUCTION AND INTERCONTINENTAL TRADE IN ANIMAL AND PLANT FOODS—Dry Basis

KIND OF FOOD	BILLIONS OF POUNDS		PER CENT
	Production	Trade	Trade
Animal	113	2.7	2
Plant	1,717	64.8	4
Animal food, per cent	6	4	–

moves from one continent to another compared with four per cent of that from plants.

Almost nine-tenths of the world's intercontinental trade is in cereals and other seed products (table 7). Wheat alone is almost half, and wheat and corn are two-thirds of this trade. Highly perishable products like fruits, vegetables, and animal products are a relatively unimportant part of the tonnage.

Table 7. APPROXIMATE INTERCONTINENTAL TRADE IN FOOD PRODUCTS—Dry Basis

KIND OF FOOD	BILLION POUNDS		PER CENT	
Grain *				
Wheat	31.3		46	
Corn	14.5		21	
Barley	4.0		6	
Rice	3.1		5	
Other	6.1		9	
Total		59.0		87
Sugar		5.2		8
Animal products		2.7		4
Fruits and vegetables		0.6		1
TOTAL		67.5		100

* Including those used for livestock feed.

CONSUMPTION

The world consumes annually about 1,400 pounds of food per capita (table 8). Consumption varies from about 1,200 pounds in Asia and Africa to 1,600 or more pounds in North America, Europe, and Oceania. In terms of dry matter, world consumption averages 558 pounds per capita. Consumption is highest in Europe and lowest in Asia, but the difference is not large. The amount of dry matter consumed varies less than the total intake. This is due primarily to the ratio of the amount of animal products to grains. The latter have the lower moisture content. North Americans consume about a third more food than Asiatics, but the difference in dry matter is only four per cent. The world needs no social uplifter to equalize the amounts of dry matter consumed on different continents. More inequality exists in the types of foods eaten than in the amount. The Eskimo lives on frozen fish, blubber, and reindeer meat, taken straight. The tropical man consumes mostly plant food; he eats little meat. Between these two extremes there is a wide range in the proportion of plant and animal products in man's diet. For the world, animal products represent 9 per cent of consumption, but the percentage varies from 3 for Asia to 25 or more for North America and Oceania (table 9). The North American consumes more animal food in a day than the Asiatic does in a week. The European has a relatively high standard of living. He consumes about twice as much of the highly prized foods as the world average, and only a third less than the North American.

TABLE 8. APPROXIMATE ANNUAL CONSUMPTION OF FOOD

CONTINENT	TOTAL, BILLION POUNDS		PER CAPITA, POUNDS	
	Wet	Dry	Wet	Dry
Asia	1,411	627	1,223	543
Europe	947	338	1,647	587
North America	307	104	1,668	567
Africa	190	86	1,210	545
South America	122	49	1,371	552
Oceania	20	6	1,818	572
WORLD	2,997	1,210	1,381	558

Judging from Asia, which is always hovering around the starvation line, it would appear that at least 500 pounds of dry matter are needed to prevent starvation. On the other hand, it would seem that a diet of over 600 pounds probably results in too much waistline, or the gout, or both. The difference between too little and too much is probably smaller than is commonly thought. Some say that the Asiatics eat little food because they are so poor, and that the Americans eat much because they are so wealthy. Others say that the Asiatics eat large amounts because they work hard, and the Americans eat little because they lead a leisurely life. The only leisure class in the United States consists of tramps, who do not work but have marvelous appetites. Most of these speculations are flights of imagination or reasoning from erroneous "facts."

TABLE 9. APPROXIMATE AMOUNT OF PLANT AND ANIMAL FOOD CONSUMED—Dry Basis

CONTINENT	PER CAPITA, POUNDS			PER CENT
	Animal	Plant	Total	Animal
Asia	16	527	543	3
Europe	97	490	587	17
North America	143	424	567	25
Africa	21	524	545	4
South America	87	465	552	16
Oceania	208	364	572	36
WORLD	52	505	558	9

A summary of the cost of living for 29 countries confirms this evidence on world consumption, which was derived from production studies. The pounds of dry matter per capita eaten in the form of grain, other plant foods, and animal products are approximately equal whether estimated from the cost of living or the production studies [2] (tables 10 and 11):

GROUPS OF FOOD	PRODUCTION	COST OF LIVING
Grain	409	420
Other plants	97	100
Animal products	52	49
Total	558	569

---

[2] The total consumption indicated by the cost-of-living studies is slightly greater than that shown by the production studies. Most of the difference is due to the larger amount of grain reported in the cost-of-living studies.

Even by continents, the total amount of food consumed was about the same, except for South America and Oceania. The cost-of-living studies would indicate that the stalwart people of Australia and New Zealand eat only 423 pounds of dry matter, which appears to be an underestimation. Probably the South American does not eat so much as the 619 pounds indicated by the cost-of-living studies. For every continent except Europe and Oceania these studies report a higher proportion of animal foods in the diet than is indicated by production studies.

Cost-of-living studies, which include the amount of food consumed, are usually

TABLE 10. APPROXIMATE AMOUNT OF FOOD CONSUMED —Dry Basis

KIND OF FOOD	PER CAPITA, POUNDS		PER CENT
	Yearly	Daily	
Grains	409	1.12	73
Vegetables and fruits	64	0.18	12
Sugar	33	0.09	6
Milk	25	0.07	5
Meat	23	0.06	4
Fish	2	0.01	0
Eggs	2		
TOTAL	558	1.53	100

Regardless of whether the production or the cost-of-living studies are used, one is impressed with the uniformity in the amount of food consumed on various continents and with the relative importance of the plant foods, especially the grains.

Man's food is eaten to maintain life, to produce energy, and to rear offspring. The maintenance of life requires the most food and the rearing of offspring the least. A small part of the food that is consumed is thrown off as waste.

TABLE 11. FOOD CONSUMPTION FROM COST-OF-LIVING STUDIES *—Dry Basis

CONTINENT	PER CAPITA, POUNDS				PER CENT
	Grain	Other plant	Animal	Total	Animal
Asia	419	75	16	540	3
Europe	402	117	76	595	13
North America	236	201	159	596	27
Africa	371	93	100	564	18
South America	316	126	177	619	29
Oceania	181	144	98	423	23
WORLD	420	100	49	569	9

* Based on 29 countries.

---

based on such groups as skilled laborers, white-collared workers, and civil service employees. Only rarely are farm families included.

The amount of food consumed varies with man's size, physical activity, climatic environment, and the like. The people of North America presumably eat more food than do the smaller Orientals. Farmers and others who work long hours at hard physical labor consume more than those in sedentary occupations. Inhabitants of cool climates seem to use more food than do those in warmer climates.

Man consumes daily about 1.5 pounds of dry matter. Of this a little over a pound is grains, a quarter of a pound vegetables, fruit, and sugar, and a little over one-tenth of a pound of animal foods (table 10).

The average person eats annually over 400 pounds of grains, which represent about three-fourths of the total dry matter consumed (table 10). The stems, roots, saps, juices, and immature seeds of plants are second and represent 18 per cent. Plants, therefore, supply man directly with 91 per cent of his food. Milk and meat represent five and four per cent, respectively. Fish and eggs are each less than one-half of one per cent of the total.

Man eats all parts of plants. He eats the seeds, the leaves and stems, the saps, and the roots. In the case of the wheat plant, Americans and Europeans eat the seed and bed the cattle with the leaves and the stalks; the roots are left in the ground. Asiatics eat the grain of the rice plant, and use on the farm almost one-half of the straw for feed and fodder, one-third for fuel, and one-tenth for mats and the like. Everywhere man eats the leaves of the cabbage and throws the rest away. He eats only the root of the carrot and the tuber of the potato. Most fruits are an appetizing growth around a worthless seed. Unlike most other food plants, the stems and roots of fruit plants are kept year after year to produce successive crops; only the leaves and seeds are thrown away or left to rot. The sap of the sugar cane is pressed from the stems to make sugar; the seed is prevented from maturing; and the roots are used to produce another crop. The delicious maple sugar is boiled-down sap.

Wheat, rice, rye, and other seeds are the basic foods of man. They comprise four-fifths of all the plant food consumed. Some of these seeds are consumed in their natural state, whereas others

TABLE 10. APPROXIMATE AMOUNT OF FOOD CONSUMED —Dry Basis

KIND OF FOOD	PER CAPITA, POUNDS		PER CENT
	Yearly	Daily	
Grains	409	1.12	73
Vegetables and fruits	64	0.18	12
Sugar	33	0.09	6
Milk	25	0.07	5
Meat	23	0.06	4
Fish	2	0.01	0
Eggs	2		
TOTAL	558	1.53	100

Regardless of whether the production or the cost-of-living studies are used, one is impressed with the uniformity in the amount of food consumed on various continents and with the relative importance of the plant foods, especially the grains.

Man's food is eaten to maintain life, to produce energy, and to rear offspring. The maintenance of life requires the most food and the rearing of offspring the least. A small part of the food that is consumed is thrown off as waste.

TABLE 11. FOOD CONSUMPTION FROM COST-OF-LIVING STUDIES *—Dry Basis

CONTINENT	PER CAPITA, POUNDS				PER CENT
	Grain	Other plant	Animal	Total	Animal
Asia	419	75	16	540	3
Europe	402	117	76	595	13
North America	236	201	159	596	27
Africa	371	93	100	564	18
South America	316	126	177	619	29
Oceania	181	144	98	423	23
WORLD	420	100	49	569	9

* Based on 29 countries.

---

based on such groups as skilled laborers, white-collared workers, and civil service employees. Only rarely are farm families included.

The amount of food consumed varies with man's size, physical activity, climatic environment, and the like. The people of North America presumably eat more food than do the smaller Orientals. Farmers and others who work long hours at hard physical labor consume more than those in sedentary occupations. Inhabitants of cool climates seem to use more food than do those in warmer climates.

Man consumes daily about 1.5 pounds of dry matter. Of this a little over a pound is grains, a quarter of a pound vegetables, fruit, and sugar, and a little over one-tenth of a pound of animal foods (table 10).

The average person eats annually over 400 pounds of grains, which represent about three-fourths of the total dry matter consumed (table 10). The stems, roots, saps, juices, and immature seeds of plants are second and represent 18 per cent. Plants, therefore, supply man directly with 91 per cent of his food. Milk and meat represent five and four per cent, respectively. Fish and eggs are each less than one-half of one per cent of the total.

Man eats all parts of plants. He eats the seeds, the leaves and stems, the saps, and the roots. In the case of the wheat plant, Americans and Europeans eat the seed and bed the cattle with the leaves and the stalks; the roots are left in the ground. Asiatics eat the grain of the rice plant, and use on the farm almost one-half of the straw for feed and fodder, one-third for fuel, and one-tenth for mats and the like. Everywhere man eats the leaves of the cabbage and throws the rest away. He eats only the root of the carrot and the tuber of the potato. Most fruits are an appetizing growth around a worthless seed. Unlike most other food plants, the stems and roots of fruit plants are kept year after year to produce successive crops; only the leaves and seeds are thrown away or left to rot. The sap of the sugar cane is pressed from the stems to make sugar; the seed is prevented from maturing; and the roots are used to produce another crop. The delicious maple sugar is boiled-down sap.

Wheat, rice, rye, and other seeds are the basic foods of man. They comprise four-fifths of all the plant food consumed. Some of these seeds are consumed in their natural state, whereas others

THE WORLD'S HUNGER

are processed. Rice is polished, wheat is milled and ground into flour, and soybeans are pressed for their oil.

Most of the remaining fifth of our plant food is tubers, roots, stems, and sap. The tubers and roots of plants such as potatoes, cassava, and sugar beets are the most important. The stems and leaves are bulky and represent only a small part of man's diet. The saps and juices are unimportant, except for sugar cane and sugar beets.

Meat, fish, and animal products are the most highly prized, but they represent only about 10 per cent of man's diet. Of these, meat and dairy products are about equally important; fish and eggs are relatively unimportant.

Although man uses food from a long list of plants, the sources of his animal foods are limited mainly to cattle, pigs, sheep, and chickens. These animals live on plants. In most parts of the world carnivorous animals are considered inedible. Most of our meat comes from full-grown animals. Some, like steers, are eaten as soon as they approach maturity. Others, like the dairy cow and the hen, are eaten after they have served their purpose of producing milk and eggs. In the United States draft animals are not normally eaten. Under the stress of war some horse meat has appeared in a few of our markets, but this has been more important as a source of comment than as a source of food. In most other parts of the world horses, oxen, and camels are eaten after they are too old for work.

People throughout the world disagree as to what parts of the animals are edible. In the United States man eats all the sardine but is squeamish about eating some parts of the sheep. The Arabs, however, are not so squeamish and eat all the sheep. Those with strong stomachs who want more details should read *Lawrence in Arabia.*

Milk is much more important than eggs, and together they are about as important as meat. Man uses milk from dairy cows, sheep, goats, and camels. Milk is consumed in a variety of ways, as sweet and sour milk, butter, cheese, evaporated, condensed, and dried milk, ice cream, sweet and sour cream, skim milk, and the like. It has been estimated that half the world's milk is consumed in the form of sweet and sour whole milk. Butter and cheese comprise most of the remainder. Americans eat large amounts of butter and little cheese, whereas much of the rest of the world eats relatively more cheese and less butter.

Regardless of income, climate, race, religion, and the like, plants comprise most of man's diet. This is true even in the United States with its high standard of living. Although the United States' consumer spends about half of his food dollar for meats and animal products, these represent only about one-fourth of the amount eaten. In other words, a pound of dry matter from animal products costs three times as much as a pound from plants. Animal foods are so expensive that they are a luxury few people in the world can afford in quantity.

Studies of the effect of income on consumption show that animal products comprise over two-fifths of the diet of the people with high incomes. On this basis it would appear that the world would like to increase its consumption of animal foods about four or five times. If this is true, there is no shortage of wants for these products; the shortage is in the supply. Most of the world's "social uplifters" are people of means who have always enjoyed a luxurious diet and who are sympathetic toward those whose diet is less delectable. Most of them have little or no comprehension of the amount of land and human effort required to produce the grain and forage for the production of these highly prized foods. These big-hearted people bring forth many grandiose schemes to improve the diet of the world's undernourished. There is no shortage of schemes and plans for upgrading the world's diet. There is a shortage of programs containing down-to-the-earth methods of attaining this laudable aim. It is a production problem and will be discussed in the following chapters.

Chapter 3

Moisture and Temperature

THE PROBLEM of increasing production falls logically into two parts, (a) increasing the acreage of land under cultivation, and (b) increasing production on the present cultivated area. Both parts are complex subjects which crisscross many fields of science. Both are highly controversial and the object of much speculation. They are important aspects of the world's food problem, however, and cannot be ignored.

The disagreement on the possibilities of increasing the world's cultivated acreage is about as great as the disagreement between Democrats and Republicans as to which party can best govern the United States. There are those, for instance, who contend that the prospects for future expansion are good in Australia, South America, and Africa. Others ridicule this idea. One must have some appreciation of the physical and biological factors involved if he is to choose between these divergent views.

If one grasps some of the complexities of these two problems, he will be in a better position to appraise the widely different estimates of future production. To evaluate the possibilities of increasing the acreage, it is necessary to have some appreciation of climatic conditions, including moisture and temperature, as well as some appreciation of topography and of soils. The latter will be discussed in Chapter 4. To understand the problem of increasing production on the present acreage, it is necessary to know something of fertilizers, livestock improvement, new varieties of crops, farm management, and the like. These topics will be considered in Chapter 5.

At present less than five per cent of the world's land surface is used for food crops (table 12). The proportion varies from about one per cent in Oceania to twenty per cent in Europe, the world's battleground. It is less than five per cent in Asia, where half the world's population lives. Even in our North America, of which we are so proud, only six per cent is used for food production. In North America there are 1.72 acres per capita in food production. Europe, South America, and Africa have about half as much and Asia about one-fourth as much. To some persons these figures indicate that the world's acreage of food could be increased many times. The problem, however, is not so simple.

TABLE 12. APPROXIMATE ACREAGE OF CROPS *

CONTINENT	TOTAL LAND Acres	FOOD CROPS Acres	PER CENT
Asia	10,400,000,000	476,000,000	4.6
Europe	2,400,000,000	477,000,000	19.9
North America	5,500,000,000	317,000,000	5.8
Africa	7,300,000,000	152,000,000	2.1
South America	4,600,000,000	83,000,000	1.8
Oceania	2,100,000,000	24,000,000	1.1
Antarctica	3,400,000,000	0	0.0
WORLD	35,700,000,000	1,529,000,000	4.3

* Excluding hay, fallow, cotton, etc. Including grain fed to livestock.

In one sense the production of human food is simple, but in another it is exceedingly complex. When one sits down to a delicious meal, he eats a mixture of what was once rain, rocks, air, and rays of sunshine. If the housewife served bowls of rain water and rocks, the family would probably turn up their noses. They would be justified in doing so, because the human body cannot use these materials. Everyone resents even the small pieces of rock occasionally found in the spinach. Nature converts those elements into plants by means of a mysterious process called *photosynthesis.* Man points with pride to his evolutionary advancement, but neither man nor any other animal can perform the miracle of photosynthesis.

At first thought it would seem that "sunshine, rocks, and water" are not the explanation of our meat, milk, and eggs. These products, however, are basically the same elements first converted into plants and then converted by the animals into meat and livestock products. To a large extent, animals live on plants or parts of plants that man cannot or does not choose to eat. Thanks to the photosynthesis of plants and to the animal processes which change plants into meats and livestock products, dinner tables are adorned with such delicacies as beefsteak, potatoes, spinach, bread, butter, salad, and apple pie à la mode. This is, in essence, the explanation of man's food.

While it is true that all the food eaten is simply a combination of sunshine, rocks, air, and water, they must be in the proper form and proportion. It is the problem of form and proportions that makes food production highly complex. The optimist who scatters a few garden seeds in a favored spot and watches the vegetables grow luxuriously little realizes how sensitive plants are to these factors.

Sunshine is required for plant growth. The directness of the sun's rays and the amount of atmosphere through which they pass cause high or low temperatures, as at the equator or the poles. All the earth, however, has enough sunshine for plant growth. The chemical elements of the atmosphere are abundant and "as free as the air you breathe." There are, however, shortages or serious maldistributions of the other factors essential to food production.

Water is necessary for plant growth, but its mere presence is not all that is required. There must not be too much as there is in the oceans, nor too little as on the deserts. Neither can it be in a frozen form as in the polar regions. Though some water is present everywhere, most of the earth's surface has either too much or too little for plant growth.

Rocks supply what is commonly spoken of as "plant food." They must be broken up into fine particles and organic matter added before "soil" is formed. In order to support plants, the soil must contain nitrogen, phosphorus, potash, lime, and other plant foods. If it has too much or too little of any given element, plants cannot grow. There are large areas which do not have these plant foods in the proper proportions.

The "lay of the land" is important in food production. The earth's surface varies from flat areas to steep mountains. A few plants will survive on steep slopes, but most of the food is produced on the low-lying, flat areas.

Water, sunshine, and the like must be considered separately and in more detail before one can appreciate the myriads of ways in which they can combine and their effects on food production. Few persons recognize the veto power of any one factor over the others. Those who are inclined to favor the principle of "veto power by a minority" should observe its working in nature before finally committing themselves.

WATER

Water is present over the entire earth's surface, but some parts have too little and others too much. Oceans, lakes, and rivers cover three-quarters of the earth's surface. Here the water is too abundant for most plant growth. In addition there are large areas of marshes, swamps, and water-logged soils. Some plants grow on these areas but they are of little use to man. Even the driest parts of the earth's surface have some water, but not enough to support plants.

The source of most of the moisture for plant growth is the large bodies of water lying in the low spots of the earth's surface. Plants live on the land surface above the level of the oceans. Nature moves water to these higher elevations by a process that seems to contradict the law of gravity and the adage, "Water does not flow up hill." Only the final step of this fascinating but complicated process is visible—hail, sleet, snow, and rain.

The sun constantly evaporates moisture from bodies of water and land throughout the world. This moisture rises and is absorbed by the air much as a blotter soaks up ink. These invisible particles float about, combine into larger invisible particles, and finally become visible as masses of clouds. They ultimately collect into particles heavy enough to fall to the earth as raindrops.

Moisture is transported long distances by winds, another of nature's complicated phenomena. Winds are simply small currents of air in the earth's huge atmospheric blanket. It takes an enormous amount of energy to put and keep the air that is near the earth's surface in motion. Despite the common description of things as being as "light as air," the earth's atmospheric blanket has weight just as has a down puff. In fact, it has an enormous weight because there is so much of it. It is said to weigh five billion tons. The lower layer of the atmospheric blanket is under greater pressure than that higher up. Man lives under about 30,000 pounds' pressure.[1] The earth's rotation and variations in temperature, however, result in different pressures throughout the world. Some regions are normally high-pressure areas; and others, low-pressure areas. Winds are merely currents of air flowing from the high to the low-pressure areas.[2] These winds distribute both "fresh" air and rain.

The moisture which the air has absorbed and the winds have carried becomes rain when the warm, moist air is cooled. This is because cool air will not hold as much moisture as warm air. In other words, cooling literally wrings water out of the air. At 100° Fahrenheit the air in the typical family garage[3] will hold about five pounds of moisture. As the temperature declines, its moisture-carrying capacity also declines, but at a much faster rate:

TEMPERATURE, DEGREES FAHRENHEIT	WATER CAPACITY OF GARAGE, POUNDS[3]
100	5.1
80	2.8
60	1.5
40	0.7
20	0.3
0	0.1
−20	0.04

[1-3] See following page for footnotes.

When the temperature changes from 80° to 40°, the moisture-carrying capacity of the air is reduced by about three-fourths.

The "sweat" on a glass of iced tea is an excellent illustration of how cooling wrings water out of the air. The surrounding warm air strikes the glass and cools, and little drops of moisture collect on the glass.

The lay of the land and the tendency of warm air to rise cause the air to cool and the moisture to condense into clouds and then into rain. The first of these causes is well illustrated in our Northwest. Moisture-laden Pacific winds blow toward the east, bump into the mountains along the coast, and are forced upward. They cool quickly, with the result that a narrow belt from California to Alaska has an abundance of rainfall. To the east of the mountains the air moves downward, thereby becoming warmer, and its moisture-carrying capacity is increased. The result is that it seldom rains there. Similarly, India has its torrential downpours when the monsoon winds, which are heavily laden with moisture, strike the southern side of the Himalayas. The area just beyond is a vast desert. There is always heavy rainfall on the windward side of mountains if the winds are moisture-laden.

The light warm air next to the earth is always pushing upward. There is much rain at the equator because there the light, warm air is heavily laden with moisture. As it rushes upward, it cools and dumps large amounts of rain on the steaming jungles. By the same token, there is little rain or snow around the poles. This explains why it is sometimes "too cold to snow," why the amount of water in the air is greatest at the hottest time of the day, why heavy rains occur in tropical latitudes, and why precipitation is often heavier in summer than in winter.

This free work that nature does for us is little appreciated. Nature converts the ocean's water into vapor, lifts it high into the air, transports it hundreds of miles, and then drops it. One

---

[1] Fortunately, nature adjusts the pressure within man so that he can withstand this force.

[2] Severe storms, tornadoes, and hurricanes occur when the air flows from an area where the pressure is very high to one where the pressure is very low.

[3] About 2,000 cubic feet.

inch of rainfall is equivalent to over 100 tons of water per acre, and for an area the size of Texas, 19 billion tons. The energy required to do all this is beyond our comprehension; it can be vaguely realized only by one who is forced to carry a gallon of gasoline half a mile on a hot Sunday afternoon.

QUANTITY NEEDED

For commercial agriculture there must be an adequate and dependable supply of water. No plant can exist without water. What happens if water is lacking is seen when potted house plants are neglected. Water moves food from the soil to the different parts of the plant. Most of it is transpired into the air; only a small proportion becomes a part of the plant. A cornstalk producing a pound of corn uses over 600 pounds of water in its growth. Practically all this water serves the important function of transporting minute quantities of food from the soil throughout the plant; it then passes into the air.

For crop production there must be enough rainfall to meet the requirements of the plants as well as the loss of water through soil evaporation and drainage. In a humid temperate climate probably five to twenty times as much water is lost through soil evaporation, run-off, and drainage as is used by the plants. The loss is much less in cooler climates with high humidity and gentle rains and much greater in a warm, dry climate where the rainfall is frequently in the form of cloudbursts. The effect of temperature on the amount of rainfall needed can be observed in the Great Plains area of the United States. The higher temperature in Texas evaporates annually about five inches more rainfall from the soil than is evaporated in North Dakota which has the same rainfall but is 1,500 miles to the north.

Rainfall varies from year to year. The agriculture of an area is largely determined by the low rainfall years. Large areas in South Africa and Australia have enough rainfall during some years, but it is too unreliable for crop production. On the other hand commercial agriculture is highly developed in our corn belt and in Europe, because the rainfall there is both adequate

and dependable. Between these extremes there are areas where farming is attempted without too much success. A few wet years will bring an influx of settlers, who leave in dry years like the "Okies" who migrated from the dust bowl to California. Yet the Okies had an easy time compared with those who try to farm the poorer two-thirds of the earth's land surface.

It is also possible to have too much rainfall. This may cause waterlogged soils in which most plants do not thrive. Other damaging effects of too much rainfall are leaching and erosion. *Leaching* is a fifty-cent word for the washing of the fertility out of the top soil. *Erosion* is the process of washing away the top soil and cutting gullies here and there. The largest areas with too much rainfall lie around the equator—the Netherlands Indies, western Brazil, northeastern India, and the Gold Coast of Africa. The Amazon Basin carries away the torrential downpours of South America.

If rain does not fall at the time of the year when the crops need it, a so-called adequate rainfall is in reality inadequate. Large areas would have sufficient rainfall if it fell during the right stage of plant growth. One of the crucial times is when the plant is maturing. It has been estimated that one-sixth or more of all the water needed for an annual crop is used in a ten-day period.

Most of the world's food is produced in areas having from 20 to 80 inches of rainfall annually. The ideal is difficult to define because the requirements of different plants vary widely. The wheat of Russia's prairies and steppes and of our Great Plains does not require as much water as the corn of Illinois or the rice of China. The ideal is perhaps 30 to 40 inches annually.

AREAS WITH SATISFACTORY RAINFALL

No part of the earth's surface lacks rain entirely, but the moisture is distributed unequally. An area in northern Chile averages 0.02 of an inch yearly and another in northeastern India over 400 inches.

Much of the land surface has too little or too variable rainfall to support the production of food crops. The outstanding areas of unsatisfactory rainfall are the Polar regions, most of Australia, and an enormous area extending from Dakar and Casablanca across northern Africa through Arabia and Teheran and into the heart of China and Siberia.

About one-third of the earth's land surface has sufficient rainfall, reasonably well distributed from year to year, to produce crops (table 13). The proportion of the land area with sufficient rainfall varies widely among the different continents. Europe has the highest proportion of well-watered land; there over three-fourths of the area has sufficient rainfall for crop production. South America is second, but a goodly proportion of that continent gets too much rain, which leaches the soils. Although North America ranks third, it has large areas with insufficient rainfall. Only about one-fourth of Asia, the largest continent, has an adequate rainfall. About one-tenth of Oceania has sufficient rainfall; most of it is barren waste.

TABLE 13. APPROXIMATE LAND AREA WITH AN ADEQUATE AND RELIABLE RAINFALL *

CONTINENT	TOTAL LAND Acres	LAND WITH ADEQUATE RAINFALL Acres	PER CENT
Asia	10,400,000,000	3,000,000,000	29
Europe	2,400,000,000	1,900,000,000	79
North America	5,500,000,000	2,100,000,000	38
Africa	7,300,000,000	1,800,000,000	25
South America	4,600,000,000	3,200,000,000	70
Oceania	2,100,000,000	200,000,000	9
Antarctica	3,400,000,000	0	0
WORLD	35,700,000,000	12,200,000,000	34

* Rainfall averaging 15 inches or more annually, except in equatorial areas of high evaporation where 40 inches was used, and varying from normal from year to year less than an average of 20 per cent.

CORRECTING NATURE'S "MISTAKES"

The earth's surface enjoys enough rainfall so that if it were properly distributed, commercial agriculture could be maintained over most of the land surface. The principle of equality, now so highly esteemed, is ignored in the distribution of rain, and down through the ages many attempts have been made to correct this inequality. The best way to do this would be to control the rainfall. The trouble has been that no one knew how to do this except the "rain doctors," and they would not tell. And so it has been proposed to redistribute the water after it has fallen. By means of irrigation man has attempted to supplement too little rainfall during the growing season.

The area under irrigation is a small proportion of the earth's land surface, about six-tenths of one per cent (table 14). Irrigated areas are most extensive in Asia, North America, and Europe.

TABLE 14. APPROXIMATE AREA UNDER IRRIGATION

CONTINENT	TOTAL LAND Acres	IRRIGATED AREA Acres	PER CENT
Asia	10,400,000,000	140,800,000	1.4
Europe	2,400,000,000	14,800,000	0.6
North America	5,500,000,000	26,800,000	0.5
Africa	7,300,000,000	10,300,000	0.1
South America	4,600,000,000	6,600,000	0.1
Oceania	2,100,000,000	1,200,000	0.1
Antarctica	3,400,000,000	0	0.0
TOTAL	35,700,000,000	200,500,000	0.6

The proportion of the land under irrigation is no criterion of the number of people fed on irrigated crops. Probably about a quarter of the world's population lives on irrigated crops.[4] Nor is the number of people now eating such crops any criterion of the future possibilities of irrigation.

There is an abundance of land to be irrigated and of water with which to irrigate it. The trouble is that they are usually too far apart. The water must not only be adjacent to the land to be irrigated, but it should be high enough so that it can be moved to the land by gravity. This means that the source of water for irrigation must be the rain that falls on nearby mountains and hills. The water is either collected in reservoirs or diverted from the rivers. For most of the earth's dry areas, central Australia, the Sahara Desert of northern Africa, and central Asia, no such water supply is available.

---

[4] Irrigation and double cropping are widespread in Asia. The fact that an Asiatic's diet is 90 per cent plant food enables irrigation to support a huge population on a relatively small acreage.

Most of the land now under irrigation is in southeastern Asia, adjacent to the Himalayas. These high mountains originate a multitude of rivers and streams, which flow south into India and Burma and east into China. About two-fifths of the earth's population lives in the adjacent area, much of which is irrigated. India irrigates almost one-quarter of its cropland, and China about one-half.

The Rocky Mountains provide water for some irrigation in the United States. The Imperial Valley of California draws its water from the Rockies. The Columbia River will irrigate a part of the Northwest. Between the Rocky and the Sierra Nevada Mountains is a vast area of fertile soils where there is insufficient moisture for crop production. The adjacent mountains, however, have insufficient rainfall to originate the rivers and streams so important to irrigation projects. Consequently the part of this vast area that can be made productive is small. The amount of land that can be irrigated by gravity is a small proportion of the area of the United States. Land could also be irrigated by pumping, but this method will not be used extensively until food is much more valuable compared with labor than it is likely to be for some time to come.

In most of the older, densely populated parts of the world, irrigation has long been developed nearly to the limit. More irrigation is possible in some of the less densely populated areas. In the United States, for instance, it has been estimated that an additional area equal to that now under irrigation could be developed. The problem is whether such irrigation would be practical. The costs of irrigation include (a) the initial costs of construction of dams and ditches and (b) the costs of maintenance and operation. The initial cost of unwise ventures can be written off as poor investments, which automatically eliminates the annual interest and principal payments. The annual costs of maintenance and operation are, however, continuous and large, and cannot be written off. For most projects the annual cost of maintenance is all the farmers can afford to pay. Much of the land that has been irrigated has not paid the original cost and gives no promise of doing so.

As the population increases, there will be more attempts to supplement the world's food supply by irrigation. It seems reasonable to assume, however, that during the next few generations the additional food from these efforts will not materially increase supplies.

The idea of "rolling back" the oceans for purposes of farming captivates the imagination. Many interesting stories have been written about Holland's dykes. Such projects could be profitable only in areas like Holland, where large markets are near and climatic conditions are almost ideal for food production. For most of the world these schemes are more useful for fiction than for increasing the world's food supply.

Where there is too much water in the soil, man drains off the excess. There are two types of drains, the open drains and underdrains. The former are merely extensions of nature's drainage system—rivers, creeks, and streams. These open drains also serve as outlets for the underdrains. Drainage, like irrigation, is an expensive process. In many areas the increased crops do not pay the interest and principal payments and the annual charge for maintenance of the ditches and drains. There are, no doubt, some areas throughout the world where more drainage would be practical, but any additional food from this land would be a negligible part of world production. The Pontine marshes, south of Rome, were drained during the twenties—an accomplishment widely publicized by Benito Mussolini. The future will reveal whether the additions to the food supply were worth the costs.

Down through the ages one of the most important problems that have confronted man has been correcting nature's mistakes —too much or too little moisture. From the standpoint of area, man has not been very successful in correcting them. From the standpoint of increasing the production of food, however, he has been very successful. About one per cent of the earth's land area had been irrigated or drained, and this small area probably feeds from one-third to half of the world's population. Although drainage and irrigation have greatly increased food production, they offer less promise for the future.

HEAT AND LIGHT

Once the sun was regarded as the source from which all the good things of life flowed, and man was a sun worshiper. Sunshine is a prime mover of civilization as it is the source of life and power, but the present generation is not so impressed as were its progenitors, the sun worshipers.

The sun is a gigantic ball of fire, almost three million miles in circumference, a million times as big as our earth, and a hundred times as hot as our hottest days, 100° in the shade. Fortunately, the earth is about 100 million miles from the sun, and only an infinitesimal part of its energy reaches us.

The sun is the source of both the heat and the light necessary for plant growth. Heat is necessary to maintain the environmental conditions, principally temperature, in which plants can live and grow. Light is the source of energy for plant growth. Both come from the sun and are, therefore, closely associated. They should not be confused, however, because their functions are different.

Plants can be grown with artificial heat and light, but such means are seldom used except in laboratory experiments to prove that they will work. The cost of artificial heat and light is so great that they cannot be given much consideration in a discussion of increasing the world's food supply. In greenhouses, where only a minute part of our out-of-season food is grown, the heat of the sun is trapped and is supplemented, when necessary, by artificial heat. Expensive man-made heat and light cannot compete with the unlimited, costless supply from the sun.

HEAT

The sun is the source of heat for the earth's land and water surfaces and for the atmospheric blanket that surrounds the earth. The sun shoots out tremendous streams of energy in all directions, but its effectiveness, so far as the earth is concerned, depends on the angle at which these rays hit the earth and the length of day. The earth is wrapped in an atmospheric blanket which is supposed to be about 300 miles thick [5] and which rotates with the earth. The temperature is high at the equator because the vertical rays of the sun pass through the least amount of atmospheric blanket and strike the earth a direct blow. It is cold at the poles because the sun's oblique rays must pass through much more of this insulating atmospheric blanket, which absorbs and scatters the sun's energy, and because the rays are spread over a wide area. Between these two extremes there is a wide range of temperatures.

The temperature of an area is lowered if there are clouds of moisture or dust in the air. On the Sahara, clouds of dust are more frequent than clouds of moisture. On the Aleutian Islands and in Newfoundland, England, and Normandy, clouds of moisture are much more numerous than clouds of dust.

Another factor affecting temperature is the length of the day. Obviously, if other things are equal, more of the sun's rays will reach Chicago during its fifteen hours of summer daylight than during a nine-hour winter day.

As the rays pass from the sun to the earth, a little heat is absorbed by the atmospheric blanket. The temperature of the air, however, depends primarily on the heat reflected from the earth's land and water. In other words, heat literally bounces back into the air and is caught by that part of the atmospheric blanket immediately adjacent to the earth's surface. This being the case, the bottom of the atmospheric blanket, where man lives, is warmer than that higher up, where he flies.

The earth has two atmospheric blankets. The one near the earth may be cold, warm, or hot at different times and places. The temperature of this inner blanket is about the same ten miles above Guadalcanal, six miles above Duluth and Paris, and three and one-half miles above the North Pole. The temperature of the outer blanket, the stratosphere, is always cold and always the same regardless of whether it is over Guadalcanal, Paris, or the North Pole.

---

[5] This blanket keeps the earth warmer than it otherwise would be, just as a blanket on a bed keeps man warm.

Water is a better transmitter of heat than land. The sun's rays can penetrate the water and warm up a large mass. Since the sun's energy cannot penetrate the land, its surface warms up quicker and gets hotter than the surface of the ocean. By the same token, the land cools off more rapidly than the ocean.[6] The seashore climate, therefore, tends to be more mild than the inland. The Riviera of France, our Atlantic City, and Argentina's Mar del Plata became resorts for this reason. Similarly, for a few miles around inland bodies of water the air warms up slowly in the spring and cools off slowly in the fall. Farmers long ago observed this fact and planted fruit trees there for protection against the hazards of early blooming and against late spring and early fall frosts. Consequently, fruit was planted in narrow belts around the shores of the Great Lakes, from New York to Wisconsin, and in similar areas around the world. Those who attempt to widen these narrow belts harvest some fruit and many bitter experiences.

The earth's atmospheric blanket is like a glass house in that it lets the sun's heat through but retards its escape. Therefore, it is warmest on the underside near the earth. This is important because it produces currents of air. Since warm air is lighter and less dense than cool air, the warm air near the earth pushes up. Stated another way, the heavier cold air far above the earth's surface presses down and displaces the warm air. Warm air is like a cork in a pan of water; it will not be kept down. The principle that unevenly heated air moves around is the basis of the "hot-air furnace"; the hot air pushes upward, creating little drafts in the living room. Similarly, warm summer air over New Orleans rushes up and out to displace the cooler air around Chicago. Chicago's heat waves are usually from southerly winds. Cold winter air from Canada sometimes rushes down and southward and frosts the fruit and vegetables from Texas to the Carolinas and spoils the fun of Florida's aging vacationists. Blizzards and big freezes usually come with north winds.

---

[6] Far inland in the United States July is the hottest month and January the coldest, whereas on the Atlantic Ocean August is the warmest and February the coldest.

If one can visualize the sun's rays striking the earth's surface at various angles and through various degrees of cloudiness in the atmospheric blanket as the earth swings around the sun and spins on its axis, then he can understand that myriads of differences in temperature are possible from hour to hour, day to day, and season to season over the earth's surface.

From the standpoint of temperature, the earth can be divided into three enormous areas. The tropics are a vast winterless belt, where there is no lack of sunshine or heat for plant growth. In the huge summerless regions of the polar areas temperatures are too low for anything except meager plant life. Between these extremes are the areas with warm summers and cool winters where most of the world's food is produced.

The temperature is high enough for plant growth on over four-fifths of the earth's surface (table 15). In no area is it too

TABLE 15. APPROXIMATE AMOUNT OF LAND WITH SUFFICIENT HEAT

CONTINENT	TOTAL LAND Acres	AREA WITH SUFFICIENT TEMPERATURE * Acres	PER CENT
Asia	10,400,000,000	9,400,000,000	90
Europe	2,400,000,000	2,300,000,000	96
North America	5,500,000,000	3,900,000,000	71
Africa	7,300,000,000	7,300,000,000	100
South America	4,600,000,000	4,500,000,000	98
Oceania	2,100,000,000	2,100,000,000	100
Antarctica	3,400,000,000	0	0
WORLD	35,700,000,000	29,500,000,000	83

* Temperature over 55° Fahrenheit during peak of growing season.

high for food production. The temperature is adequate during the growing season for most of Africa, Oceania, South America, and Europe. About half of the area with too low temperatures is in Antarctica, and the other half in North America and Asia. Although North America is only about half as large as Asia, it has almost twice as much land too cool for crop production. Except for Antarctica, North America has the smallest proportion of land with suitable temperatures.

LIGHT

The known effects of light on plant growth are many and complicated, and much about the subject is as yet unknown. Light is essential to plant growth. Without light there would be no production of plant chlorophyll and no absorption of carbon dioxide by the plants. Therefore, without light there would be no plant life on the earth's surface. Photosynthesis is a process evolved by nature to enable plants to utilize the sun's energy. The process is not very efficient. Less than one per cent of the radiation falling on plants is used.

Light is available everywhere, though in varying amounts. At the equator the sun shines about 12 hours a day the year around, whereas at the poles it shines 24 hours a day in the middle of summer and is completely lacking in the dead of winter. In fact, the farther one travels toward the poles, the greater the plant growth on a summer's day because there are more hours of daylight. Factors other than light retard plant growth around the poles.

Despite its importance, light cannot be considered as seriously limiting food production on any part of the earth.

CARBON DIOXIDE

Carbon is essential to plant life. By photosynthesis plants manufacture carbohydrates from water and the carbon dioxide of the air. The air is largely nitrogen and oxygen and contains only three-hundredths of one per cent of carbon dioxide. Although a

The World's Hunger

By Frank A. Pearson *and* Floyd A. Harper

Cornell University Press
Ithaca, New York 1945

minute part of the air, carbon is about 40 to 45 per cent of the dry matter of plants. This has confused many persons as to the source of the plant's carbon supply. A large volume of air must be depleted of its carbon dioxide to supply plants. An acre of corn is estimated to deplete about 20,000 tons of air of its carbon dioxide to obtain the carbon in the plants. Despite the huge quantity used by plants, the amount of carbon dioxide in the air remains relatively constant. Gases escaping from volcanoes, the decay of organic matter, the combustion of fuels, the respiration of plants and animals, the disintegration of rocks, especially limestone, and changes in the salts of the oceans presumably replace the carbon dioxide used by plants. The oceans are important also because they equalize the carbon dioxide content of the air.

Experiments show that increasing the supply of carbon dioxide accelerates the rate of photosynthesis, but there is no evidence that world food production will be increased by this process. Food production can be increased in greenhouses by maintaining a larger supply of carbon dioxide. When carbon dioxide is released in open fields, however, it is quickly dispersed through the atmosphere.

The supply of atmospheric carbon dioxide is uniform over the world. Until man can devise ways of increasing, redistributing, or using increased supplies, there is no promise of increasing world food supplies by the use of carbon dioxide.

Chapter 4

Land Forms and Soils

LAND FORMS

THE EARTH is an approximately round ball 8,000 miles in diameter and 25,000 miles in circumference, with a surface aggregating almost 200,000,000 square miles. It is covered by an irregular, tough, and rocky hide. *Land forms* is a ninety-nine-cent word the scientists developed for convenience in describing the cover on this huge ball. The two main divisions of the earth's surface are the great depressions which are filled with water and the exposed continental surfaces. Some of the ocean's depths and mountain peaks approximate six miles below and above sea level. Mountains, hills, plateaus, and plains are the important but little-appreciated continental land forms. Of lesser importance, but better known, are the small hills and the dales, the gullies, and the small plains of every community. These major and minor land forms are the result of geologic, biologic, and climatic processes, operating gradually through time. Some of the effects of these forces can occasionally be seen within a lifetime, but they are usually observable only over millions of years.

The earth, like the old maid, will not tell her age, but this reticence does not prevent us from gossiping. Some contend that she is young, a few hundred thousand years perhaps, and others that her age is many billions of years. Old Mother Earth is so aged that no one can recall her early history. About the latter part, say the last 500 million years, a little is known. In her youth the earth acquired a crust, which is mainly rock and which contains most of the chemical elements. How she acquired this costume and how its rocky texture was tailored are interesting subjects of speculation, but they are beyond the scope of our problem. The processes of wearing down the coat of many colors, however, are important to our understanding of food, because it was by these processes that the land forms were made.

The earth's crust was changed by bending, warping, and breaking, and by heat, winds, and chemical action. Pieces of it were moved from one place to another by heat, gravity, winds, water, glaciers, and the like. These forces are all more or less in constant conflict. Some of the forces bend the earth's surface, making mountains, and other forces wear them down.

Erosion is constantly taking place and is both beneficial and harmful to man. In some places it builds up lands which can be used by man, and in others it destroys lands that nature has built up. Millions of years of erosion were necessary to make our fertile plains; now millions of dollars are being spent to prevent them from eroding. The forces of nature, however, are so powerful and so persistent that they overwhelm the feeble, erratic, and ineffective efforts of man. In a few million years, our fertile corn belt soils may be deposited in the Gulf of Mexico and we may be on a diet of rice instead of pork.

PLATEAUS

Relatively level lands that lie at a considerable elevation, about 2,000 feet or more above sea level, are called *plateaus*. There are large plateaus in Tibet, Mongolia, Mexico, and the western part of the United States. Much of Africa and Arabia and parts of Australia and India are relatively nonvaluable tablelands. Although plateaus are likely to be dry, parts of the Brazilian Plateau, the Deccan Plateau of India, and the Congo Basin of Africa receive heavy rainfall. There are also great ice plateaus, such as those in Greenland and Antarctica.

HILL LANDS

Hill lands are easier to visualize than to describe. They are neither mountains nor rough plains. They are usually old, weathered highlands. Hills with gentle slopes are cultivated or pastured. Even though hill lands are of little value, they may contain fertile valleys. The Allegheny-Cumberland hill region extending from southern New York to Alabama is typical of many hill lands the world around. The greatest hill area in the world is in eastern Asia, extending southward from Siberia to southern China. The valleys are fertile and support a large population.

MOUNTAINS

Mountains are characterized by their height and are long on vertical, but short on horizontal, surfaces. A large proportion of their surface is on their steep slopes and a small proportion on the top. The slopes are so steep that they are of little agricultural value. The important mountain areas of the world are the Rocky and Andes Mountains of the western Americas, the Himalayas of Asia, the Alps of Europe, and the Caucasus of Russia. They occupy large amounts of space, they affect rainfall, and they are barriers to the movement of commodities and people. The Himalayas have prevented invasion of India from the north.

PLAINS

Spatially and economically the plains are the most important class of land forms. They are a higher proportion of the land surface, produce more food, and have a larger share of the centers of population than either hills, plateaus, or mountains. Plains are low-lying lands. Some are near sea level and others are relatively high. Some are flat and others are rolling. Plains have been classified in many ways. Only a few will be discussed.

Coastal plains were settling places for sand worked over by the ocean's waves and currents. The United States has a great coastal plain extending from New Jersey down the Atlantic coast and across the southern states to Texas.

Delta plains are soil deposits at the mouths of rivers. They are usually flat and fertile and frequently support dense populations. The most famous is the delta at the mouth of the Nile River. Other important deltas in dry areas are those of the Tigris-Euphrates of Iraq and the Indus of western India and our Imperial Valley along the Colorado River. The Yellow River, carrying huge amounts of yellow silt from central China, built up a delta at its mouth in the Yellow Sea. Another great Chinese delta at the mouth of the Yangtze supports a huge population centering around Shanghai. The delta is highly productive, and it has been shown that farmers there have a much higher standard of living than those elsewhere in China. They eat better food, wear better clothes, and live in better houses.

Floodplains are fertile deposits along the banks of the rivers. The most famous are those of the Nile. For centuries periodic floods have deposited silt, constantly renewing the soils along the banks of the Nile. The Yellow River overflows its banks and deposits silt along its course. The bottom lands of the lower Mississippi are floodplains. There are great and important alluvial deposits along the middle and upper Ganges of northeastern India, the Indus River of western India, the Tigris and Euphrates of Iraq, and the Yangtze.

Loess plains are accumulations of soil transported by winds. Areas of Kansas, Nebraska, Iowa, and Illinois are illustrations. There are large areas in northwestern China. There is a long strip extending from central Germany through Poland and across southern Russia. The Argentine Pampas are covered with loess soils, which in some places are as much as 500 feet thick.

Glaciated plains are common in the northern parts of Europe and North America. Some are ice-scoured and others drift plains. Canada, Norway, Sweden, and Finland have ice-scoured plains. The glaciers dropped their debris farther south. Much of Holland, Denmark, northern Germany, Poland, and eastern Russia are drift plains. Our drift plains extend from the Missouri River east to Maine, and from the Great Lakes south to the Ohio River.

From a half to two-thirds of the world's dairy products are produced on glacial plains.

Arid desert plains, like those of our Southwest, the Sahara Desert, and central Australia, are usually of low productivity.

Most of the world's population lives on the plains of China, India, western Europe, southern Russia, and the United States. The plains of Africa, Arabia, Turkestan, and Australia do not support many people because of lack of moisture.

DISTRIBUTION OF LAND FORMS

The earth's land surface is about one-quarter mountains and hills, one-third plateaus, and two-fifths plains (table 16). The distribution around the world is rather uneven. Europe has few land forms that curtail food production. Two-thirds of its land surface has been classified as plains and only four per cent as mountains. Africa is literally a huge plateau. It has a smaller proportion of its land in mountains, hills, and plains than any other continent, 3, 1, and 25 per cent respectively. Asia has the most equitable distribution of land forms, about one-fourth in each class.

TABLE 16. APPROXIMATE AREA IN MOUNTAINS, HILLS, PLATEAUS, AND PLAINS

CONTINENT	AREA, MILLION ACRES					PER CENT			
	Total	Mountains	Hills	Plateaus	Plains	Mountains	Hills	Plateaus	Plains
Asia	10,400	2,100	2,500	2,500	3,300	20	24	24	32
Europe	2,400	100	500	200	1,600	4	21	8	67
No America	5,500	700	600	1,300	2,900	13	11	24	52
Africa	7,300	200	100	5,200	1,800	3	1	71	25
So. America	4,600	500	400	1,100	2,600	11	9	24	56
Oceania	2,100	200	400	500	1,000	9	19	24	48
TOTAL *	32,300	3,800	4,500	10,800	13,200	12	14	33	41

* Excluding Antarctica.

From the standpoint of land forms, about two-thirds of the earth's surface is usable for food production. Excluding Antarctica the proportion ranges from 56 per cent in Asia to 86 per cent in Oceania (table 17).

TABLE 17. APPROXIMATE AMOUNT OF LAND WITH FAVORABLE TOPOGRAPHY *

CONTINENT	TOTAL LAND Acres	USABLE LAND Acres	PER CENT
Asia	10,400,000,000	5,800,000,000	56
Europe	2,400,000,000	1,500,000,000	63
North America	5,500,000,000	3,900,000,000	71
Africa	7,300,000,000	5,700,000,000	78
South America	4,600,000,000	3,200,000,000	70
Oceania	2,100,000,000	1,800,000,000	86
Antarctica	3,400,000,000	800,000,000	24
TOTAL	35,700,000,000	22,700,000,000	64

* Based on the assumption that 5 per cent of the mountains, 25 per cent of the hills, 75 per cent of the plateaus, and 95 per cent of the plains can be used.

SOILS

The interior of the earth is said to be molten rock under great heat and pressure. The earth's surface is composed of hard rocks, probably from five to ten miles thick. As this surface cooled and contracted, earthquakes warped the crust and volcanoes squeezed out molten rock at weak points. Little of this rocky crust is now visible because most of it is covered with the waters of the oceans or by the soils of the land surface. Although physically the soil is an insignificant part of the earth or its crust, it is most important to man because it produces his food.

FORMATION OF SOILS

Plants cannot grow until soils have been formed. Soils are merely outer parts of the rocky crust that have been broken down and have accumulated organic matter. Many forces work to disintegrate the earth's rocky crust into its soils—freezing, thawing, glaciers, winds, water, chemicals, bacteria, worms, plant roots, and animals. These forces have been in operation for billions of years.

Rocks are broken down by chemical and mechanical weathering. The chemical action takes place with the aid of water and the gases in the air. The rusting of iron is a similar process. Complex chemical procedures change the size, shape, and composition of the rocks. Mechanical weathering is also necessary to the development of our soils. Alternate freezing and thawing cracks the rocks and breaks off pieces. The roots of plants grow into rock crevices and contribute to the breakdown. Glaciers scrape off the protruding tops of the rocks, gouge out large areas, and grind them up into gravel, sand, silt, and clay. The glaciers may deposit this material hundreds of miles from where it was picked up.

Various forms of plant and animal life add organic matter to the soil. The decay of plants is the most important source of organic matter. Bacteria, worms, insects, and burrowing animals, in serving their own selfish ends, improve the soil. The soil is literally alive with plants and animals so small that they cannot be seen with the naked eye. They cause decay in fallen leaves and dead plants. Larger animals, such as earthworms, moles, and woodchucks, burrow in the soil and move it around. Still larger animals roam the surface. Most of these convert plants into soil organic matter.

Water moves pieces of rock and soil particles here and there, and in the process breaks them into finer pieces. The constant beating of ocean waves grinds away rocky coast lines. The waves and tides deposit the sand at other places near the water's edge. In fact, much of the seaboard from New Jersey to Texas is a vast sand deposit made by the ocean. The rivulets, creeks, streams, and rivers wear down rocks, pebbles, and sand as they flow merrily on to the lakes and oceans. They carry fine particles which they drop as the rate of flow declines. Here and there gravel beds, sand bars, or deltas of fine silt are formed. These deltas may be a few square rods or a few square miles in size, or they may be huge areas as at the mouth of the Nile, the Ganges, and the Mississippi rivers. The overflow of streams and rivers deposits some material on the flat areas along their courses. The floodplains of the Nile are a striking illustration.

The winds are also powerful forces causing translocation.

They move small pebbles and sand a few feet or a few miles and carry silt hundreds of miles. The loess soils of our Midwest and of great areas of Russia and China are deposits of wind-carried silt.

Climate is also related to soil formation. Chemical reactions are most rapid in a hot humid climate, but many of the soils are leached by heavy rains that wash out most of the fertility. In the colder climates of the Arctics there is considerable mixing of the soil particles by freezing and thawing, but chemical weathering is very slow. The climates of the temperate zones with their gentle rains and moderate temperatures are best for the development of productive soils.

Over uncounted centuries these chemical and mechanical forces of nature have combined to form the huge amounts of soil that now almost completely obscure that part of the earth's rocky crust not covered by water.

The quality of soils ranges from barrenness to high productivity. Some are well drained and others are not. Some are shallow and others are deep. Some are stony and gravelly, others mostly sand, and still others silt and clay. The amounts of organic matter and other plant foods which contribute to soil fertility also vary widely. In fact, there are more combinations of these conditions than the mind of man can visualize.

Nature did not observe the principle of equality when she distributed the good and poor soils over the earth's surface. In some places good soils are wasted because they have been piled hundreds of feet thick. In others soils are too thin for a productive agriculture.

TYPES OF SOILS

There are enormous areas in the tropics that produce abundant plant life. Their soils, however, are so badly leached that they contain little humus or plant food and are of little agricultural value. Some tropical soils, however, are highly productive. Java is a case in point. Its soils, which are of recent volcanic origin, have not been leached and produce huge amounts of food.

Most of the world's deserts lie just outside the tropics. Their soils are in striking contrast to those of the tropics. They are usually more fertile, but lack the moisture necessary for agriculture. That many of these soils are fertile is indicated by the productive date trees of the oases where moisture is obtainable. The great desert areas of North Africa, southwestern and central Asia, and Australia are of little agricultural value because of limited rainfall, and not because of lack of soil fertility. Like the unproductive tropical soils, the desert soils cover a substantial part of the earth's surface.

Many areas have sufficient moisture to produce grasses, but not enough to produce trees. Down the ages gradual decomposition of the grass resulted in large amounts of humus, and little fertility was lost by leaching. As a result the grasslands of southern Russia and the North American plains east of the Rockies are now very fertile. These widely scattered areas do not cover much of the earth's surface.

Some of the areas adjacent to these grasslands have similar soils with somewhat more moisture. They have an abundance of humus and plant food and are called *black prairie* soils. The rich corn belt of the United States, the Russian Ukraine, and the Argentine Pampas are of this type. These areas are of great significance in commercial agriculture although they cover only an insignificant part of the earth's surface.

Many of the forest soils of humid regions are sandy and are covered with a thin layer of decomposed plant materials. The light, sandy, relatively infertile areas of the Atlantic and Gulf plains of the United States are of this type. The extensive glaciated plains in the northern part of North America and Europe have a wide variety of soils. Some of these are rich and others poor.

In polar regions there are vast areas of so-called *tundra* soils. These treeless belts support a few reindeer on a sparse vegetation of mosses, lichens, and low-growing shrubs. Although these areas have little rainfall, there is a superabundance of moisture because of the low rate of surface evaporation and because of a permanently frozen subsoil. Just south of the tundra belt around

COPYRIGHT, 1945, BY CORNELL UNIVERSITY

CORNELL UNIVERSITY PRESS
LONDON: HUMPHREY MILFORD
OXFORD UNIVERSITY PRESS

All rights reserved. This book, or parts thereof, must not be reproduced in any form without permission in writing from the publisher, except by a reviewer who wishes to quote brief passages in a review of the book.

PRINTED IN THE UNITED STATES OF AMERICA BY THE
VAIL-BALLOU PRESS, INC., BINGHAMTON, NEW YORK

the North Pole is a vast area having long winters and short summers where coniferous forests abound. These *podzol* soils are generally acid and not very productive. Next to the tropical and desert soils these agriculturally unproductive tundra and podzol soils cover the largest part of the earth's surface.

AMOUNT OF GOOD SOILS

The innumerable kinds of soil that blanket the earth's surface are more varied and complex, but less vivid, than grandmother's crazy quilt. Temperature can be measured with a thermometer in degrees, and rainfall in inches, but no one has developed a simple and exact measure of the world's crazy quilt of soils. To simplify the problem, the authors have here classified the soils as good or poor.

A little less than half of the earth's soils are favorable for crop production (table 18). Antarctica is worthless. Africa, Oceania, and Europe have a high proportion of good soils, two-thirds to four-fifths of their areas. Over half of the good land of the world is in Asia and Africa. South America, the fourth largest continent, has the least proportion of good soils, 26 per cent.

TABLE 18. APPROXIMATE AREA OF GOOD SOILS

CONTINENT	TOTAL LAND Acres	GOOD SOILS Acres	PER CENT
Asia	10,400,000,000	4,900,000,000	47
Europe	2,400,000,000	1,900,000,000	79
North America	5,500,000,000	2,200,000,000	40
Africa	7,300,000,000	4,700,000,000	64
South America	4,600,000,000	1,200,000,000	26
Oceania	2,100,000,000	1,400,000,000	67
Antarctica	3,400,000,000	0	0
WORLD	35,700,000,000	16,300,000,000	46

In generations to come the amount of good soils may be of less importance than at the present time. Soils normally perform three functions that aid in plant growth. They provide anchorage for the roots, material upon which the plant can feed, and the moisture which helps absorb and transport the plant food. Soils perform these functions more economically than any other substance or group of substances. But it is possible, at higher costs, to produce food by using other means of performing one or more of the three functions. Along our southeastern seaboard soils provide anchorage and water, while man provides much of the plant food. In Asia soils provide anchorage and plant food, while man supplies the water. Experimentally, gravel provides anchorage, while man provides water and plant food. In other experiments man provides water and plant food in tanks and supports the plants on racks, thereby producing food without soil. While such methods extend the possibilities of future food production, their practical adoption awaits the day when food shall be much more valuable relative to materials and labor than it is at present.

LIMITATIONS JOINTLY CONSIDERED

The possibilities of greatly increasing the world's crop production would appear to be highly favorable if one judged solely by the amount of rainfall (table 19). Almost one-half of the earth's land surface has sufficient annual rainfall for crop production, but less than five per cent is now in crops exclusive of hay. Most of the 43 per cent with adequate rainfall cannot be used for crop production because the rain does not come at the right time of the year, or it is not dependable, or the temperature is not favorable, or the soil is too poor, or topography interferes with man's attempts to produce crops.

Likewise, if one considers only temperature, over four-fifths of the earth's surface is satisfactory (table 19). About two-thirds is satisfactory from the standpoint of topography, and almost one-half from the standpoint of soils. There is no scarcity of adequate light or carbon dioxide.

If the agricultural possibilities of the world were appraised on the basis of these factors considered separately, one would conclude that adequate rainfall is the limiting factor and that about two-fifths of the earth's surface is suitable for production. This is too optimistic because not all this land has fertile soils nor is it blessed with reliable rainfall, favorable temperature, and satisfactory topography. A satisfactory agriculture can be maintained only if all conditions are favorable. This is an excellent illustration of minority rule, as each factor has a veto power over the others. Only a small proportion of the earth's land surface has all the essentials necessary for crops. About one-third has an adequate climate; about one-fifth, both adequate climate and topography; and only one-fourteenth, the required combination of climate, topography, and soil.

TABLE 19. EFFECT OF VARIOUS COMBINATIONS OF FACTORS LIMITING FOOD PRODUCTION

		LAND AREA ADAPTED TO FOOD	
		Acres	Per cent
INDIVIDUAL FACTORS			
	Adequate sunlight	35,700,000,000	100
	Adequate carbon dioxide	35,700,000,000	100
	Favorable temperature	29,500,000,000	83
	Favorable topography	22,700,000,000	64
	Reliable rainfall	16,600,000,000	46
	Fertile soil	16,300,000,000	46
	Adequate rainfall	15,500,000,000	43
COMBINATION OF FACTORS			
Number	Combination		
1	Sunlight	35,700,000,000	100
2	Carbon dioxide *and sunlight*	35,700,000,000	100
3	Adequate rainfall *and carbon dioxide, sunlight*	15,500,000,000	43
4	Reliable rainfall *and adequate rainfall, carbon dioxide, sunlight*	12,200,000,000	34
5	Temperature *and reliable rainfall, adequate rainfall, carbon dioxide, sunlight*	11,400,000,000	32
6	Topography *and temperature, reliable rainfall, adequate rainfall, carbon dioxide, sunlight*	7,400,000,000	21
7	Soil *and topography, temperature, reliable rainfall, adequate rainfall, carbon dioxide, sunlight*	2,600,000,000	7

The proportion of the world's land adapted to crops, seven per cent, is greater than the area now in crops other than hay, four per cent. However, the amount of good farm land that man has overlooked is small. In most instances, enthusiasm as to the agricultural possibilities of some new region is based on only one or two of the necessary factors. For instance, to those living in moderately dry communities the large undeveloped tropics with an abundance of rainfall and sunshine appear to have tremendous promise for agricultural production. Large areas in the tropics, however, have poor, leached-out soils which automatically eliminate them from commercial agriculture as effectively as inadequate rainfall eliminates the Sahara Desert. Some students are more optimistic as to the possibilities of increasing crop production than other students or the world's farmers. Baker estimated that almost one-fifth of the earth's surface is arable,[1] and Penck held that the world could feed nearly four times its present population.[2]

Europe has the highest proportion of its land area adapted to food production, 37 per cent; North America is a poor second with only 10 per cent (table 20). More emigrants have left Europe to farm in other areas than have left any other continent. This would indicate that little chance exists for expanding acreage in Europe. Immigration into the agricultural areas of North America has slowed down to a trickle, indicating a general belief that there is not much opportunity there for expansion. Certainly no great hordes of immigrants are rushing into Asia, Australia, or Africa. The fact that immigrants are still moving to South America in large numbers indicates that there may be some possibilities of expanding food production there by taking up new lands. During the past decade or so, however, most of the world's immigrants have been seeking work in the industrial centers of their adopted country rather than taking up its unoccupied farm lands. Apparently these immigrants have been skeptical of settling on lands not already occupied by "the natives." Immigration data, therefore, indicate that not much additional acreage can be devoted to food production.

---

[1] O. E. Baker, "Land Utilization in the United States," *Geographical Review*, XIII (Jan., 1923), 25.

[2] A. Penck, "Das Hauptproblem der physischen Anthropogeographie," *Zeitschrift für Geopolitik*, Halbband I, Heft 5, Blätter 330–348, May, 1925.

For centuries untold millions have ventured into areas where they usually could not produce sufficient food for existence. Our books are filled with the successes. They create a wrong impression of the chances of winning in such undertakings because they do not record the uncounted millions of pioneers who failed. Spectacular successes like the pioneering in America are rare. The popular novelist portrays a courageous family who went to Iowa in a covered wagon and established a fine farm. Only occasionally do novelists, in the interest of accuracy, risk sales by recording unsuccessful attempts.

TABLE 20. PROPORTION OF CONTINENTS ADAPTED TO AGRICULTURAL PRODUCTION *

CONTINENT	TOTAL LAND AREA	ADAPTED TO AGRICULTURAL PRODUCTION	
	Acres	Acres	Per cent
Asia	10,400,000,000	600,000,000	6
Europe	2,400,000,000	890,000,000	37
North America	5,500,000,000	570,000,000	10
Africa	7,300,000,000	240,000,000	3
South America	4,600,000,000	220,000,000	5
Oceania	2,100,000,000	60,000,000	3
Antarctica	3,400,000,000	0	0
WORLD	35,700,000,000	2,580,000,000	7

* Based on the combination of amount and reliability of rainfall, temperature, soil, and topography.

Although unforeseen new techniques of food production may be developed, those who would plan for the future of the world had best be conservative as to the prospects for expansion. In the main, expansion of the world's agriculture beyond the area now being used is a hazardous undertaking. The requirements of nature for food production are so rigid that thus far man has been able to use only a small proportion of the earth's land surface and has been defeated in most of his attempts to extend his boundaries.

Chapter 5

Increasing Production on the Present Acreage

MANY persons will agree that there is little immediate or even long-time prospect of materially expanding world food production by bringing in new acreage. They contend, however, that it is possible to produce much more food on our present farm acreage by the use of more fertilizer, more labor, more and better machinery, improved varieties of crops, and more efficient livestock.

The world produces about half a ton of food per acre (table 21).

TABLE 21. APPROXIMATE YIELD OF FOOD CROPS PER ACRE HARVESTED *—Dry Basis

CONTINENT	POUNDS
Asia	1,046
Europe	976
North America	1,058
Africa	643
South America	1,066
Oceania	740
WORLD	

* Based on 19 crops as follows wheat, rice, corn, oats, potatoes, barley, rye, millet, sorghums, sugar cane, soybeans, sugar beets, dry beans, groundnuts, sweet potatoes, maslin, sesame, rapeseed, and spelt.

Yields in Africa and Oceania are far below the world's average. Yields for the other four continents, which produce most of the food and support most of the people, are reasonably uniform despite wide differences in crops grown, methods of production, and climate. North America, with its high-yielding corn crop, large farms, and highly mechanized agriculture, produces about the same amount per acre harvested as does Asia with its high-yielding rice crop and small farms using largely manual labor and little machinery.

FERTILIZER

Yields per acre, and therefore food production, can unquestionably be increased by the use of more human and animal manures and commercial fertilizers, and by plowing under "green manure" crops. Excluding sod, stubble, and refuse plowed under, animal and human manure is the most important source of fertility added to the soil by man. Commercial fertilizers are next. Green manure crops, turned under, are the least important.

Commercial fertilizers are applied to add plant food. Manures add organic matter as well as plant food. Manures also improve the texture, tilth, drainage, and aeration of the soil, and they increase its water-holding capacity. In areas with long growing seasons, as in much of the Orient, South America, and Africa, tremendous quantities of organic matter are used up each year. In the cooler parts of the world the loss is less rapid. Obviously, maintaining the organic matter of the soil is more of a problem in China and India than in Europe and North America.

Human Excreta

Large amounts of the night soil of about half the world's population, mainly Asia's teeming millions, are returned to the crop land. Most of the human excreta of the other half is lost. In the more wealthy nations a small proportion of this fertilizer is collected from the sludge basins of the city sewage systems, but it is used mostly for golf courses, lawns, and the like rather than for food production. Most of the soluble plant foods are lost. The great unused sources of human excreta are Europe and the United States, where so far the problem has been to dispose of it for sanitary reasons rather than to utilize it for food production. When food in these areas becomes scarce in proportion to population, more human excreta probably will be used for food production. There is little likelihood, however, that the world's food production will be increased by the use of this type of fertilizer for some time to come.

Animal Manures

Animal manures, composed of excreta and litter, are the most important source of fertility added to the soil by man. Even in China, where the greatest use is made of human excreta, animal manures are over four-fifths of the total.

Since China does not eat much meat or drink much milk, it is generally assumed that she has a sparse livestock population. Most of her livestock consists of draft animals, oxen and water buffaloes. The amount of livestock per crop acre is higher in China than in most other parts of the world. It is this dense animal population rather than the use of human excreta that down through the ages has maintained the fertility of Chinese soils.

In the cooler areas of Europe and North America, animals are barn-fed about six months of the year, and the manure is hauled onto the fields. Even under these favorable conditions, not more than half the manure is returned to the crop land. In areas having longer growing seasons, the number of livestock is less and more of the manure is dropped on pastures. Consequently, in warm climates there is little manure available for crops.

To increase crop yields materially with animal manures, it would be necessary to increase the number of animals or to utilize present supplies more efficiently. To expand livestock production, it would be necessary to increase the acreage of hay and pastures at the expense of the grains, and this is unlikely to occur. Crop yields could be increased by utilizing animal urine more completely and by hauling manure daily. Allowing it to accumulate in the barnyard wastes plant food. Present supplies of animal manure will be used more efficiently, however, only when food becomes more valuable relative to human labor than it now is. A general increase in crop yields either from greater amounts or from more efficient use of present supplies of animal manure is unlikely to occur in the near future.

Commercial Fertilizers

Commercial fertilizers, which are now less important than manures, can be used to increase yields in various parts of the world. With the development of commercial fixation of nitrogen, there are literally unlimited supplies of this plant food available because of the great abundance of nitrogen in the atmosphere, which can be used over and over. The known supplies of phosphate and potash are adequate to permit heavier applications where they are now being used, and to permit their use on a greatly expanded acreage.

The use of commercial fertilizers is a recent development that is increasing rapidly. The amount used is still small and is largely limited to the United States and Europe, which together consume nearly 90 per cent of the world's commercial fertilizers. They will continue to increase their crop yields by using greater amounts. The Orient uses little commercial fertilizer because of lack of readily available supplies and poor transportation facilities.

The expanding production of nitrates, phosphates, and potash has been accompanied by a downward trend in the prices of fertilizers and an improvement in farm equipment designed to handle them. These factors caused an expansion in the use of commercial fertilizer on both good and poor soils. The largest bushel increases are, of course, obtained on the good soils and the largest percentage increases on the poor soils.

Green Manure Crops

In the cooler parts of the world green manure crops are relatively unimportant because the short growing season is sufficient only for growing the main crop. In areas with a longer growing season it is possible to produce green manure crops either before or after the main crops. Much of China has a long growing season, but her farmers plow under few green manure crops. Instead, they raise another crop to feed more people.

The use of green manure crops is restricted because of the amount of human, animal, and mechanical power required to fit the land, plant the crop, and plow it under, and because of the difficulty of fitting such crops into the rotations without decreasing food production. There is no question but that yields can be increased by the expansion of green manure crops, but whether more people can be fed from the same area is another question.

There is likely to be a greater increase in food production due to expansion in the use of commercial fertilizers than to the increased use of animal and human manures, or green manure crops. By more efficient use of these materials, yields can be increased. Such additions to the world's food supplies, however, will be gradual and will extend over a long period of time. Future generations will find it difficult to measure their effects, because yields will also be influenced by expansion of acreage on poorer land, changes in weather, cultural practices, improved varieties of crops, and the like.

USING MORE LABOR

There is little possibility of increasing man's food supply by the use of more labor on our present acreage. Many persons note that potatoes, a crop on which much labor is used, produce about 115 bushels per acre, while wheat, upon which little labor is expended, produces only about 15 bushels. The conclusion is that food supplies could be increased by the use of more human labor. The difference between yields of potatoes and wheat, however, is due primarily to the crop and not to the amount of labor.

In a highly mechanized agriculture, such as that of the United States, increased applications of human labor would be accompanied by a decrease in the use of machinery. A decrease in yields would result because mechanization permits better preparation of seed beds, better cultivation, and better harvesting.

At the other extreme, as in Asia where little machinery is used, there is little opportunity for increasing yields by the use of more

Preface

THIS BOOK was written primarily for those interested in the world food problem. The authors make no special claims as authorities other than to appraise widely divergent views on the basis of the scanty information available.

There is no scarcity of land with favorable topography, or adequate sunlight and carbon dioxide, or favorable temperature, or reliable rainfall, or fertile soil, or adequate rainfall. There is, however, a serious shortage of land with the proper combinations of these seven factors that are so necessary for food production.

This book is not a compendium of geological, biological, physiological, and meteorological knowledge. An attempt has been made to relate this technical material to the world food problem so that it can be understood by the ordinary reader.

The authors wish to acknowledge the suggestions and criticisms of J. L. Buck, H. O. Buckman, P. C. Chao, H. F. DeGraff, H. B. Hartwig, R. A. Mordoff, D. Paarlberg, F. L. Platt, and G. P. Scoville; and the editorial work of M. Scudder. The full responsibility for inaccuracies, however, rests with the undersigned.

F. A. PEARSON
F. A. HARPER

human labor, since the maximum is already being used. The use of more labor per acre in Asia, though it would probably increase yields somewhat, would not sustain the additional laborers at even their present poverty level.

The application of additional amounts of human labor does not increase yields proportionately. Those who recommend this method of increasing food supplies, therefore, propose that the standard of living of the world be reduced. It would be almost impossible to carry out such proposals in a civilization with a rising standard of living.

USING MORE MACHINERY

The internal combustion engine and modern machinery for fitting the land, cultivating, and harvesting the crop were a great advance over farming with horses, and horse power was a great advance over "the man with the hoe." Each step made it possible for farmers to fit the land better, to till crops more thoroughly, and to harvest them with less loss. The sickle left more grain in the fields than the horse-drawn reaper, which in turn left more than the tractor-drawn combine. Mechanization has increased yields somewhat, but the big effect has been in the food production per farmer. This makes it possible to divert some energy to producing automobiles, more and better schools, and the like, all of which go to raise the standard of living. Mechanized equipment does not overcome the most important conditions limiting yields, the natural fertility of the soil and climatic conditions. Although mechanization increases yields and thereby production on the lands with good soils and favorable topography, it reduces production on stony land and hilly areas which are usually thrown back into pasture. Mechanization also makes it unprofitable to cultivate small fields.

The use of mechanical power replaces animal power. The amount of food available for other livestock or for man increases with a decrease in the amount fed to horses and other animals used for power. This substitution also affects the timing of farm work. For this reason heavy unseasonable rains interfere less with mechanical power than with animal power when the ground is being prepared, planted, or cultivated.

Where the standard of living is very low and labor is cheap, the mechanization of food production is almost impossible. It will be a long time before the Orient's food supply is augmented by mechanization. The problem there is to improve the hoe. In general, mechanization will increase the world's food supply, but not so much as many persons believe.

NEW AND IMPROVED VARIETIES OF CROPS

Man has increased his food supplies by finding new plants or new uses for old ones. The dwarf bush lima bean was found by a Negro along a road in Virginia about 1885. The fruit of the tomato, once called *love apples,* and thought to be poisonous, was used only for decoration. It was not eaten until about 1850 and is now one of our most important vegetables.

The sugar beet is an outstanding example of the development of a new plant in modern times. In 1747 a German scientist found a species of beets containing sugar identical to that in sugar cane, but attempts to establish sugar factories in Germany were unsuccessful. Later Napoleon subsidized sugar factories and sugar beet production to strike at England's sugar trade. With polariscopic analysis of the sugar content, improved varieties, better cultural practices, subsidies, and the like, beet production has expanded rapidly and now supplies the world with one-third of its sugar.

One of the important means of increasing food production was the transfer of plants from one part of the world to another. The pea is said to have been known to the ancient Egyptian. Corn is an American institution, centuries old. Both have spread over the world. Potatoes, native to the cooler parts of South America, were carried to the mainland of Europe and to Ireland, and are now known as "Irish potatoes." The world now produces eight billion bushels of white potatoes annually or four bushels per capita.

For thousands of years citrus fruits have been grown in the

Orient. They were introduced into Florida in 1579 and into California in 1769, but expansion in the United States did not occur until the twentieth century. The strawberry is a cosmopolitan plant. It grows wild in Iceland as well as in warmer climates. Owing to the smallness of its seeds the strawberry is one of the most widely scattered fruits.

"Turkey red" is a drought-resistant hard winter wheat from eastern Europe. It was imported into the United States and improved, and has increased our food supply by pushing wheat production farther west onto the drier lands.

The seed from which our chocolate bar is made has been known for centuries. It was carried to the Gold Coast, and now African production of cacao exceeds that of the rest of the world. The soybean, a native of the Orient, was introduced into Pennsylvania in 1804 but was unimportant until recently. During the last two decades the United States acreage has increased about ten times.

Alfalfa in Arabic means "best fodder." It has been suggested that when Nebuchadnezzar was driven into the field and ate "grass," he really ate alfalfa. In 1857 Grimm, a German immigrant, brought a few alfalfa seeds from his homeland to the United States. For fifty years he patiently saved seeds from plants that survived Minnesota's rigorous winters. Now Grimm alfalfa, a hardy plant, is a byword with American farmers.

Down through the ages man has improved crops by the trial and error method. It was not, however, until Mendel's laws of inheritance were discovered and rediscovered that rapid progress was made in improving varieties by scientific plant breeding. During the last half century this procedure has resulted in important increases in food production through greater yields per acre. The most recent spectacular development was hybrid corn, which has increased our corn belt yields 15 to 20 per cent.

Plant scientists are combing the earth for new plants and new varieties. The plant breeders are developing new strains which are higher in food value or resistant to drought, disease, insects, and the like. Some of these improvements increase yields on the present acreage, and others make it possible to produce food in areas where it was not formerly grown. These methods will continue to augment man's food supply.

DOUBLE CROPPING

In many parts of the world more than one crop is produced on the land each year. Double cropping is practiced extensively in Asia, but only to a limited extent in the rest of the world. Double cropping is best measured by the percentage of the crop area having more than one crop yearly. The index of double cropping for China is 149. On the average, China produces a crop and a half on every acre. Double cropping varies with climatic conditions. In northern China farmers produce one crop on the land, and in southern China, almost two; the indexes are 107 and 176, respectively. The size of the farm does not appear to affect the amount of double cropping, but the type of crop is an important factor. Rice seedlings are planted immediately following the harvest of the first crop. Under the most favorable conditions, as many as three crops of rice are raised each year.

Double cropping has not been extensive on any continent except Asia. It is necessary to have a long growing season and an abundance of rainfall or water for irrigation. Excluding Asia, most of the world's food is produced in areas with a short growing season, which automatically prohibits double cropping. In most parts of the world where the season is long enough for double cropping there is insufficient moisture. There is little likelihood that world food production can be increased materially by double cropping.

LIVESTOCK IMPROVEMENT

Man lives largely on grasses. His grains are the seeds of such grasses as rice and wheat. His meat, milk, and eggs are transformed grasses—mostly stems and stalks. Although progress has been made in improved breeds of livestock, these advances have not increased man's food supply as much as has the improvement of crops.

The larger animals have a slow rate of reproduction. Self-fertilization, which speeds the work of the plant breeder, cannot be used by the livestock breeder. In the case of livestock, it is difficult to separate the effects of inheritance from those of environment, but with plants this is not so difficult. The number of animals with which man can work is almost insignificant when compared with the number of plants. Man can multiply a few varieties of plants rapidly and at relatively little expense. With livestock, however, the slower rate of multiplication makes rapid progress much more difficult.

In the case of livestock, attention was generally directed toward appearance. One group developed the Shorthorn cattle, another the white-faced Hereford, and a third the black Angus. More attention was given to color, size, and form than to improving cattle as a converter of plants that man cannot or will not eat.

Practically all the cattle once performed the triple function of supplying labor, meat, and milk. In much of the world this still holds true. In China cattle are kept primarily for labor, and meat is a by-product. In India also they are kept principally for labor; hides and ghee [1] are by-products. In western Europe, the Americas, and Oceania the horse and the internal combustion engine are the primary sources of power, and cattle are used for meat and milk production. During the last century there has been a widespread tendency to select cattle for either meat or milk, so that today the dairy cattle are quite distinct from the beef cattle. The separation of these functions increased their food production for man.

Rapid strides have been made in breeding other types of livestock. Our corn belt hog, a descendant of the wild boar and the razorback, has been bred to produce a maximum of meat and fat. Rapid progress has also been made in developing poultry for egg production. Egg production per hen has risen steadily, because of better feeding and better breeding. With the introduction of commercial flocks many disease problems have arisen and emphasis is now being placed on disease-resistant strains.

Continued improvement in the efficiency with which livestock converts feed into meat, dairy, and poultry products may be expected. The increased production, however, will not feed many people nor is livestock improvement as promising as that of crops.

---

[1] Butterfat in a liquid or semisolid form, capable of being kept for a considerable period of time.

Food production can be materially expanded on the present crop area by more complete conservation of animal manures, the expansion of commercial fertilizers, the use of more machinery, more efficient livestock, new and improved varieties of crops, control of animal and plant diseases, and more double cropping. These methods seem to hold more promise for increasing the world's food supply than does an expansion of acreage. Changes, however, will be slow and gradual, with little likelihood that they will contribute much during any one generation. In fact, the expansion will probably be less than the growth of population. This forecast is based on our present knowledge. Of course, farmers or scientists may make revolutionary discoveries. These possibilities, however, have been left to the Jules Vernes.

Chapter 6

Food from the Water

ALMOST three-fourths of the earth's surface is covered with water. This vast area supplies man with less than half of one per cent of his food. Since "seaweed salads" have never become popular, most of the food from the oceans, lakes, and streams has been fish, lobsters, oysters, shrimp, and the like.

In view of the insignificant quantities of food now taken from these vast water areas, it would seem that the world's food problem could easily be solved by more fishing. There are, however, only a few areas in the oceans that are populated by large numbers of edible fish, easily caught. A large proportion of the world's fishing grounds are in the cooler waters of the northern hemisphere. These grounds are within about 250 miles of the coasts and in waters less than 1,200 feet in depth. Fishing is most extensive around Europe from the Mediterranean Sea to Norway, around Japan and the shoals of China, and around North America from Cape Cod to the banks of Newfoundland and from Oregon to Alaska.

Fish, like man and the other animals, live either directly or indirectly on plants. Marine plant life is of two main types. One is a group of minute unrooted plants that grow near the surface of the water. The more important group consists of the algae rooted to the ocean's floor.

Like land plants, marine plants live on sunlight, water, and plant food. Since water is not a problem, the limiting factors are sunshine and plant food. The sun's rays penetrate water only about 600 feet, and so marine plants grow largely in the shallow waters near land. Because of this fact most of the fish of the sea live in the shallow waters near the land, just as most of the people on the land live at the low elevations near the sea.

Most of our commercial fish, like herring and mackerel, live near the surface and are caught with nets. Others, like cod, are caught at greater depths with trawls and baited hooks on a line, but this method is uneconomical below 2,000 feet.

Because of lack of sunlight and plant food, most of the earth's vast water areas are literally deserts, supporting little life. Probably about five per cent of the ocean contains an abundance of plant life, a percentage which approximates the small proportion of the earth's land surface producing food for man. Even in the small part of the sea which has sufficient fish to make it worth while to attempt to catch them yields are low. For instance, in the English Channel, which is one of the world's rich fishing spots, the catch has been estimated at only about five pounds per acre. This is equivalent to about one pound of dry matter per acre, compared with about 2,000 pounds of corn per acre raised on Iowa's rich soils.

If man's food supply is to be increased greatly by more sea food, it will be necessary to discover new fishing grounds, to eat more kinds of fish, or to devise ways either of catching more fish or raising more. There is always the possibility of discovering new fishing grounds, but in his long struggle for existence man must have searched the oceans rather thoroughly. Some increase in food could occur by eating species now considered inedible, but this would probably not increase consumption much. The problem, then, becomes one of getting more fish from present grounds. To fish them more intensively would increase the catch for a time, but it would lead to a decrease later. Evidence of the effects of overfishing appeared after World War I when intensified fishing in the North Sea resulted in a drop in both the daily catch and the size of the fish. Our fish supplies will, therefore, be limited until man finds ways of raising more fish. This calls for more plant food for the fish, and as yet no practical way has been devised to increase the ocean's plant life. The prospect of delivering sunshine to more of the ocean's floor is about as fantastic as that of irrigating the Sahara Desert or of warming up Antarctica.

It seems reasonable to assume that fish will continue to be an unimportant part of the world's diet. The ocean, like the land, is a vast area, most of which will produce little or no food for man. Though some life can be found everywhere, the "yields per acre and per hour of work" are so low over most of it that man cannot survive on the product of his labor. The earth's vast water areas are much more important to man as a source of rain for his land crops, as a regulator of temperature to cool his summers and warm his winters, and as his cheapest means of transportation than they are as a source of his food.

Chapter 7

Food and Population Problems

FROM the Stone Age to the present time man has been looking for the "promised land" where he can have a more abundant life. He has had no lack of leaders in this search. There is nothing to indicate that food will not continue to be a pressing problem in most parts of the world. In fact, food will probably be a more important problem in the future than it was during the past century when production was expanding in the "new world." It is on this period, however, that many persons base their optimistic predictions of the future trends in world food production.

Over half the world's population lives in Asia, which is by all odds the largest continent (table 22). A little over one-fourth live in Europe, which is one of the smallest. The remaining one-fifth is scattered over the other four continents which comprise about half the world's land surface.

There are many ways to measure density of population. The usual method is the amount of land per person. On this basis, the world is long on land and short of people since it has about 16 acres of land per inhabitant. Europe, the most densely populated continent, has four acres per capita. Asia is a close second, with only nine acres. Oceania, the least densely populated, has nearly 200 acres per person. This test of density is not very satisfactory because of differences in the proportion of good land on the various continents. The world's greatest swarms of people are in the great food-producing areas. Most of the world's largest cities are in, or near, these areas. Millions of people discovered and settled the fertile areas long before the geographers and economists observed that they were there.

A more satisfactory test of the density of population is the amount of grain produced per person. Grain represents about three-fourths of man's food. On this basis, Asia and Africa are the most densely populated continents. Both produce about a quarter of a ton of grain per person (table 22). North America and Oceania are the least densely populated, with over three-fourths of a ton of grain per capita. Asia has about half the people and produces a little less than half the grain. Europe has the same proportion of the world's population and of its grain production, 27 per cent. North America is the only continent where there is a striking dissimilarity; it has less than a tenth of the population but produces one-fifth of the grain. In general there is an uncanny relationship between continental populations and the food produced.

TABLE 22. WORLD POPULATION AND GRAIN PRODUCTION

CONTINENT	POPULATION	GRAIN	PROPORTION OF		ACRES PER PERSON	GRAIN PER PERSON
		Pounds	Population	Grain		Pounds
Asia	1,154,000,000	683,000,000,000	53	41	9	592
Europe	575,000,000	453,000,000,000	27	27	4	788
North America	181,000,000	342,000,000,000	8	20	30	1,859
Africa	157,000,000	95,000,000,000	7	6	47	605
South America	89,000,000	86,000,000,000	4	5	52	966
Oceania	11,000,000	17,000,000,000	1	1	191	1,545
WORLD	2,170,000,000	1,676,000,000,000	100	100	16	772

POPULATION THE WORLD CAN SUPPORT

The number of people the world food supply will support is dependent upon the standard of living. At present the world supports a little more than two billion people, but on an uneven standard of living. Oceanians, North Americans, and Europeans eat well, but even they do not eat so well as they would like.

If the world would accept the Asiatic standard, our present grain production would support almost three billion people,[1] an increase of about 30 per cent over the present population (table 23). Since Asia has the lowest standard of living, the population on each of the other continents would be increased. The greatest increase would occur in North America, and most of the remainder in Europe.

TABLE 23. APPROXIMATE NUMBER OF PERSONS THAT GRAIN SUPPLIES COULD MAINTAIN ON DIFFERENT STANDARDS

CONTINENT	PRESENT POPULATION	NUMBER OF PERSONS IN MILLIONS UNDER		
	Millions	Asiatic standard	European standard	North American standard
Asia	1,151	*1,154*	866	368
Europe	575	765	575	241
North America	184	577	134	*184*
Africa	157	160	121	51
South America	89	146	110	46
Oceania	11	29	21	9
WORLD	2,170	2,831	2,127	902

Under a North American standard of living, the present world production would maintain fewer than a billion persons, or less than half the present population. The greatest reductions would occur in Asia and Europe, and there would be no continent with an increase.

If the European standard of living, as measured by grain, were to be the criterion, the world's population would remain about the same but its location would change. The greatest changes would occur in Asia and North America. This standard would call for about the same increase in the North American population as the decrease in that of Asia.

Although there is little opportunity to upgrade the world's food habits in terms of total intake, there is thought to be a wonderful opportunity to upgrade the standard of living in terms of what is eaten. An increasing number of persons are becoming internationally minded. The aim of some is to better their own welfare; others, less selfish, want to help those hundreds of millions who are the world's "downtrodden third." Better diets, i.e., more milk, meat, and eggs, for these people can come only by (1) dividing more equally the world's present production of these highly prized foods, (2) increasing production of these foods on the poorer continents, or (3) reducing the number of people on the densely populated continents.

---

[1] This does not take into consideration the grain that could be produced on the hay and tillable pasture lands.

If the world's animal foods were rationed on the basis of an equal amount for all, there would be about one pound weekly per person. To attain this equality, it would be necessary for North America to reduce its consumption by two-thirds, Europe by one-half, and South America by one-third. Asia and Africa would then consume about three times as much of these products as at present.

In the United States political capital has been made of sympathy for the lower third, and various schemes have been proposed to raise its standard of living. It is interesting to note what the effect of world leveling would be on the diets of our poverty-stricken citizens. The lowest third in the United States consumes about 120 pounds, dry, of animal products a year. To attain complete world equality, that is, 52 pounds per capita on each continent, our lower third would be deprived of over half of its livestock products.

Equalization can be attained by giving food to the poorer nations or by moving the people from the low- to the high-standard continents. Those who would equalize international welfare by redistributing food after it has been produced might better be supporting free immigration as a more practical means of accomplishing the objective. It would be much cheaper to move a 140-pound person once, than to move some 1,400 pounds of food every year.

The second solution, increasing production, is apparently the hope of those who plan a bounteous future for the world's dinner table. Some well-fed persons propose that the world's food habits be upgraded to their own level without any sacrifice on their part. To suggest that this can be done by increasing production of the highly prized foods is to propose the impossible. These foods are produced from grasses and grains. In most areas it is practically impossible to increase the production of forage. In some the people eat practically all their grain, leaving little for animal feed. For them to feed more of their grain to livestock in order to have a better diet is one sure way to starve. Folks would rather live on their present diet than starve on a more palatable one.

Vociferous liberals and champions of the common man have voiced such objectives as "a quart of milk for every Hottentot." Anyone who seriously proposes such objectives is fostering false hopes and, if believed, promotes international misunderstanding. Even in the United States a quart of milk a day would be difficult of attainment. The proposal becomes fantastic when applied to the world. Present milk production would be only one-third enough. To produce the extra amount would require the equivalent of enough grain to feed the present world population. This is in addition to the grain, pasture, and other roughage the world is now producing.

The third solution, reducing the population, would be very effective. But the international planners have not yet brought forth even the agenda of such a plan. War, pestilence, and famine are methods of attaining this end, but every effort is made to prevent or curtail them. In fact, they are considered worse than a lower standard of living. Unless a satisfactory and acceptable substitute for these methods of curtailing population can be found, agreed upon, and put into operation, there will be no freedom from either war or want. World War II reduced the population and brightened the prospects of more meat, dairy and poultry products for those who survived, but proposals are now being made to increase the population by glorifying or subsidizing motherhood.

There is no shortage of plans and planners. There are those who would reduce disease. Others plan to end all wars, to prevent starvation and malnutrition, to eliminate fear and want, or to raise the standard of living. Still others plan for more children for future defense. Many of these plans are essentially in conflict with one another. As in the past, wars, diseases, and famines will be major forces restraining the population.

EUROPE'S WARTIME FOOD PROBLEM

Some, not realizing how high Europe's standard of living already is, believe it should be upgraded with more of the highly prized foods. If the only two continents which have a higher standard, North America and Oceania, were to divide with Europe, it would be necessary for North America to reduce its standard of living in terms of these foods by about one-fourth, and Oceania by one-half. Since Europe has so many people and such a high standard of living, each person's share would be increased by only an eighth.

Many believed that starvation and serious malnutrition were widespread in Europe and that this was due to the blockade which shut off imports of food from other continents. Articles, pictures, and other propaganda led to this general belief. Those parts of Europe whose trade was unobstructed by the Allied blockade, namely England, Ireland, Spain, Sweden, and Portugal, took about half of the European food imports before the war (table 24). These countries took most of the imported livestock products and two-fifths of the grain. The Allied blockade probably reduced Europe's imported grain by about 35 billion pounds annually, which is a little more than one-tenth of its total food consumption. Much of this would have gone to the Netherlands and Denmark which, before the war, imported about 32 billion pounds of grain and by-products. It would probably have been fed to livestock to produce eggs, pork, and dairy products for export to England and other European countries.

As a result of the blockade, there was a reduction in the production of meat and dairy and poultry products, and the people ate rye, barley, and low-quality wheat, which were formerly fed to livestock. The heavy-grain consumers, hogs and poultry, were liquidated more than the light-grain, heavy-forage-and-pasture consumers, dairy and beef cattle, sheep, and goats.

If the imports of grain that were interrupted by the blockade could have been fed to Europe's livestock, they would have produced about five billion pounds of livestock products. This represents only about two per cent of normal consumption. If the blockade reduced livestock production five billion pounds,[2] Europeans would have had to eat an additional six billion pounds of grain. This is enough change to cause considerable comment, but not enough to cause widespread hunger.

TABLE 24. APPROXIMATE EUROPEAN IMPORTS UNINTERRUPTED BY THE BLOCKADE—Dry, Billion Pounds

	NORMAL IMPORTS	UNINTERRUPTED* IMPORTS
Animal	2.7	3.0
Grain	59.0	24.1
Other	4.9	5.5
TOTAL	66.6	32.6

* England, Ireland, Spain, Portugal, and Sweden.

Western Europe is truly the largest garden spot of the world. It produces more food than any other continent except Asia, which is much larger. Despite its 575 million people, it has a high standard of living and feeds more grain to livestock than any other continent. Widespread famine is not likely to occur where large amounts of grain are normally fed to livestock. If harvests are poor, or food is wasted or destroyed, human beings kill and eat the livestock, and then eat the grain formerly fed to the livestock. During this war Europe made such adjustments and managed amazingly well. The only serious food threat was an extremely poor harvest, which rarely occurs in Europe.

---

[2] A reduction of five billion pounds in the consumption of livestock products would result in a diversion of five billion pounds of grain from livestock feed to human food. This grain would have produced nearly a billion pounds of livestock products, which would also have to be replaced with grain, or a total of about six billion pounds.

Europe has sufficient food to maintain herself during prolonged wars. Although the standard of living will decline, she will even then be far above the low level experienced by Asia's teeming millions. Asia, unlike Europe and North America, has no shock absorber of livestock, which normally use large amounts of grain. The result is that wars or poor harvests quickly bring starvation to millions. Japan is vulnerable because she has no livestock and imports much of her food.

North America has many surplus and deficit food areas. For instance, New England is a great deficit area, and Illinois and Iowa are surplus areas. Similarly, Europe has both surplus and deficit areas. In the deficit areas, the war brought starvation and malnutrition. But this was due not to an over-all shortage of food, but to the chaos of war and the disruption of the channels of trade. There were, of course, the inevitable wastes of war, which were impossible to estimate.

When the Allies landed on the Normandy Coast in the summer of 1944, there were stories about food being rushed to France's civilians. At the same time there were other stories that the invading Allied armies found that food was abundant there and that the people were generally well fed. This amazed all who had pictured the European continent as a mass of starving humanity. Anyone who had studied a little agricultural geography knew that this part of France was highly productive and supplied Paris and other adjacent cities with food.

Europe had many food-deficit pockets that could not be supplied with food from other continents during the war. These areas had widespread starvation and malnutrition. During the war their population was reduced to the food available from adjacent areas. The relief and postwar needs of such areas should not be measured in terms of their prewar populations. In our enthusiasm to aid these areas, it should be remembered that no amount of food will revive those who starved.

When there is less propaganda and more fact, it would not be surprising to find that there had been much less distress in Europe than was anticipated. When the soldiers return to their peacetime activities, Europe will certainly produce large amounts of food, as she did before the war, for a population materially reduced in numbers.[3] Farmers of surplus-food continents should not overestimate the postwar European market. Of course, it will always be a good market for free food, but consumers on the "surplus" continents will object to the adoption of such a policy.

EUROPE, THE DANGER SPOT

It is obvious that there is an uneven distribution of the continental populations relative to grain supplies. Since food production is the most important factor limiting population, it is to be expected that the danger spots would be those with large and dense populations and little grain, the world's principal food. Africa has a low production of grain per capita, but the population is small and widely scattered over the second largest continent. For these reasons Africa is not likely to be a serious problem.

From the standpoint of food supplies alone, Asia is generally considered the world's real danger spot. Her people are not accepted as immigrants in other parts of the world, and so starvation, disease, and the war lords keep the population in adjustment with the food supply at a subsistence level. The standard of living, however, is so low that the nations of Asia cannot build up the reserves necessary for a gigantic conflict.

Only the richest parts of the world can afford the luxury of starting struggles like either World War I or II. Europe is the danger spot. It is rich in agriculture and other natural resources and has a great industrial plant. It has had a high standard of living, which has been rising. It has the second largest continental population, which has been increasing. For over a century the

---

[3] This discussion applies to Europe as a continent and not to problems of distribution that may arise in any European country under unpredictable foreign administration.

Contents

CHAPTER 1 Introduction 1

CHAPTER 2 Production, Trade, and Consumption 5

CHAPTER 3 Moisture and Temperature 19

CHAPTER 4 Land Forms and Soils 37

CHAPTER 5 Increasing Production on the Present Acreage 51

CHAPTER 6 Food from the Water 63

CHAPTER 7 Food and Population Problems 67

Appendix and Bibliography 81

Index 85

excess spilled over into North and South America. As long as this was possible, Europe was not embroiled in great wars.[4] This honeymoon for Europe is over, however. Recently Europe has found it difficult to find outlets for its excess population or markets where its industrial products can be traded for food. Although wars may arise from a wide variety of causes, such as the ambitions of ruling classes, religious differences, and the like, most of them arise from actual or imagined economic differences. Hitler stated the fundamental causes of war very simply and clearly—more *lebensraum*. Since there are so few of the good things of life and they are so unevenly distributed, there is plenty of incentive to attempt to redistribute them. Past history does not indicate that this equality will be established by voluntary or peaceful methods. It is more likely that the stronger groups of men will seize, or attempt to seize, fertile valleys, plains, or countries from their weaker neighbors, if they feel that they do not have adequate food supplies. World Wars I and II were attempts at redistribution, and, as the pressure of population on the food supply increases, there will be more. The more integrated and interdependent the relationships between continents become, the more likely it is that trouble will arise.

If Europe is to maintain its increasing population and high standards of living, it must continue to export more and more manufactured products from its industrial centers and import more food in exchange. Since this is becoming increasingly difficult, however, violent explosions are likely to occur unless some kind of action is taken to dissipate them. Unfortunately, few persons can forecast changes in this delicate mechanism, see them as they occur, initiate effective remedies, or do anything to overcome them.

During the past forty or fifty years Europe has experienced difficulty in obtaining increasing supplies of the cheap food that was so abundant prior to about 1900. Furthermore, Europe's industrial plant has met increasing competition from other continents. Food exports from the United States declined rapidly from about 1900 until about 1912, when the nation began to import more food than it exported. This was a period of relative scarcity. The world price level was rising, and world food prices were rising more rapidly than other prices. The expression, "the high cost of living," was coined in the United States and soon became world-wide.

---

[4] During the last nine centuries the intensities of European wars rose sharply, but fell in the eighteenth century and declined sharply in the nineteenth. With the twentieth century the intensity again rose sharply.

During the sixteenth and seventeenth centuries the major European countries were at war about 65 per cent of the time, but during the eighteenth and nineteenth centuries the percentage declined to 38 and 28 per cent, respectively.

Europe was also disturbed by the so-called American invasion, a European term for the rapid expansion of industrial exports from North America. This invasion was no myth. Since the nineties the exports of finished manufactured goods of the United States have risen from 15 to almost 50 per cent of the total. Over a relatively short time the United States suddenly changed from an exporter to an importer of food, and from an importer to an exporter of manufactured products. Furthermore, as the new continent became settled, it set up restrictions, quotas, and the like against immigration from Europe. This was a perfect setting for a gigantic struggle by nations for their "place in the sun." The blame, however, was laid on those areas or persons that made strenuous efforts to correct the real or presumed inequities. The Kaiser was generally believed to be the cause of World War I just as Hitler was blamed for World War II. They merely personified the underlying causes. Europe had been finding it more and more difficult to sell increasing amounts of manufactured products in order to buy increasing amounts of cheap food with which to maintain an increasing population and to support a rising standard of living.

Around the turn of this century the pressure of population on food supplies stimulated a rapid expansion in the "science of agriculture." The number of agricultural colleges and experiment stations increased rapidly, and those that had been established prior to this period expanded their work. The world-wide problem was "to make two blades of grass grow where one grew before." Huge amounts of money were poured into agricultural research, extension, and teaching in many countries, with the aim of increasing supplies, improving efficiency, and reducing the costs of man's food.

After the close of World War I, commodity prices declined for about two decades. Since falling prices are generally associated with increasing supplies, it was thought that there was an abundance of food. The "surplus" idea increased gradually during the twenties and rapidly during the thirties. The professors of soils, agronomy, and plant breeding, whose job it was to increase production, lost their place in the sun to those economists who had a myriad of plans for the disposal, curtailment, and prevention of the imagined surpluses. Countless programs were started and billions of dollars were spent in attempts to curb production and "buy" scarcity. During the latter part of this period the ill-fed and undernourished were discovered, rediscovered, and suddenly brought into the foreground. These two ideas—abundance and scarcity—are incompatible.

Even with the so-called surpluses, food supplies did not keep pace with population, and there were many barriers to the movement of food. Europe continued to have difficulty in finding markets for increasing amounts of manufactured products.[5] The expanding industries of Japan, China, India, Canada, and the United States made these areas less dependent on Europe's industrial plant than formerly. The decreasing market for Europe's industrial products and the increasing difficulty of obtaining food under the restrictions set up because of the so-called world surplus resulted in either a leveling off of the rising standard of living that Europe had long experienced or an actual decline. Such a condition is a perfect setting for a world-wide struggle. Some groups hoped to maintain or raise their own standard of living with more food and greater markets for their products by expanding the *lebensraum*. Others were interested only in self-protection.

Europe is still the largest producer of manufactured products and the largest importer of food. It is most dependent, therefore, on the free flow of products through international trade. Regardless of our theories in favor of free trade, there has been a tendency to raise trade barriers. As the world population expands, this trend will doubtless continue. If regimentation becomes the order, countries will become more nationalistic and less internationally minded than they would be with a free economy.

---

[5] The export market for steel is very important to western Europe, which produces about as much steel as the United States. Our exports represent about 7 per cent of our production, whereas European exports range from 21 per cent for Germany to 94 per cent for Belgium and Luxembourg.

There are straws in the wind indicating that Europe will continue to be faced with the problem of increasing competition. This will call for an adjustment in her population or her standard of living. In the process there are likely to be quarrels among those countries which have the highest standards of living and are most dependent on world trade.

If, after World War II, some parts of the world continue to think that they are suffering from a shortage of food while others have a surplus, they will make war in the attempt to obtain a more equitable distribution of the good things of life. It seems reasonably clear that there are no large areas of new land to be brought into cultivation, that each continent will tend to manufacture an increasing proportion of the products it consumes, that immigration will continue to be restricted, and that there will be insufficient controls to prevent population from expanding. In that event Europe, as in the past, will be the real danger spot in the world.

Appendix

IT WAS not possible to date the statistical information on consumption and production because of the lack of comparable data. The data on consumption studies extend from the twenties to the thirties. As far as possible the data on production were for the thirties, immediately preceding World War II. The data, therefore, are approximations and are so designated in the tables.

Pounds of dry matter were used instead of calories because of the difficulty of visualizing a calorie.

Since this manuscript was prepared for the layman and not for the economist, scientist, or statistician, details and specific references were omitted. Most of the scientific and statistical information were taken from the sources listed in the bibliography.

BIBLIOGRAPHY

The following is a partial list of the books and articles on the many factors affecting world production and consumption of food that were used by the authors.

Bacon, L. B., and Schloemer, F. C. World Trade in Agricultural Products. Rome, Italy: Villa Umberto I, 1940.

Baker, O. E. Land Utilization in the United States: Geographical Aspects of the Problem. Geographical Review, XIII, No. 1 (January, 1923).

Baker, O. E. The Potential Supply of Wheat. Economic Geography, I, No. 1 (March, 1925).

Bengtson, N. A., and Van Royen, W. Fundamentals of Economic Geography. Rev. ed. New York: Prentice-Hall, 1943.

Bennett, M. K. International Contrasts in Food Consumption. Geographical Review, XXXI, No. 3 (July, 1941).

Buck, J. L. Land Utilization in China. Chicago: The University of Chicago Press, 1937. 3 vols.

Chang, C. C. China's Food Problem *In* Problems of the Pacific, 1931. Proceedings of the Fourth Conference of the Institute of Pacific Relations, Hangchow and Shanghai, China, October 21 to November 2. Chicago: The University of Chicago Press, 1932.

Chatfield, C., and Adams, G. Proximate Composition of American Food Materials. Washington, D.C., 1940. U.S. Department of Agriculture, Circular No. 549 (June, 1940).

Clark, C. The Conditions of Economic Progress. London: Macmillan and Co., 1940.

Crawford, W., and Broadley, H. The People's Food. London: William Heinemann, 1938.

Davis, D H. The Earth and Man. New York: The Macmillan Co., 1943

DeCandolle, A. Origin of Cultivated Plants. New York: D. Appleton & Co., 1908.

East, E. M. Population in Relation to Agriculture. *In* Eugenics in Race and State, Second International Congress of Eugenics, Vol II. Baltimore: Williams & Wilkins Co., 1923.

Finch, V. C., and Baker, O. E. Geography of the World's Agriculture. Washington, D.C., 1917. U.S. Department of Agriculture, Office of Farm Management.

Finch, V. C., and Trewartha, G. T. Elements of Geography. New York: McGraw-Hill Book Co., 1936

Goode, J. P. Goode's School Atlas. New York: Rand McNally & Co., 1939

Great Britain, Imperial Economic Committee. Vegetable Oils and Oilseeds. London: His Majesty's Stationery Office, 1936, 1937, 1938

Great Britain, India Office. Statistical Abstract for British India. London: His Majesty's Stationery Office, 1929.

Hannay, A. M. The Influence of Weather on Crops, 1900–1930. A Selected and Annotated Bibliography. Washington, D.C., 1931. U.S. Department of Agriculture, Miscellaneous Publication No. 118 (October, 1931)

Huntington, E. The Human Habitat. New York: D Van Nostrand Co., 1927.

Huntington, E., and Cushing, S. W. Principles of Human Geography. New York: John Wiley & Sons, 1921.

Huntington, E., Williams, F. E., and Van Valkenburg, S. Economic and Social Geography. New York: John Wiley & Sons, 1933.

The Indian Year Book, 1943–44. Vol XXX. London: Bennett, Coleman & Co., Ltd., n.d.

International Institute of Agriculture. International Yearbook of Agricultural Statistics, 1938-39. Rome: International Institute of Agriculture, 1939.

Israelsen, O. W. Irrigation Principles and Practices. New York: John Wiley & Sons, 1932.

Kendrew, W. G. Climate. Oxford: The Clarendon Press, 1930.

Klages, K. H. W. Ecological Crop Geography. New York: The Macmillan Co., 1942.

League of Nations. The Network of World Trade. Geneva: League of Nations, 1942. Series of League of Nations Publications II. Economic and Financial, 1942. II. A. 3.

BIBLIOGRAPHY

Lyon, T. L., and Buckman, H. O. The Nature and Properties of Soils New York: The Macmillan Co., 1943.

Migone, R. C., Abeiastury, M. F., Fuente, E., and Iturraspe, J. E. Inter American Statistical Yearbook. New York: The Macmillan Co., 1942.

Miller, E. C. Plant Physiology. New York: McGraw-Hill Book Co., 1938.

Morimoto, K. The Standard of Living in Japan. Baltimore: The Johns Hopkins Press, 1918. Johns Hopkins University, Studies in Historical and Political Science, Ser. XXXVI, No. 1.

National Industrial Conference Board. The Cost of Living in Foreign Countries. New York: National Industrial Conference Board, Inc., 1927.

Olcott, M. T. World Food Supply: A Selected Bibliography. Washington, D.C., 1925. U.S. Department of Agriculture Library, Biographical Contributions No. 9 (June, 1925).

Penck, A. Das Hauptproblem der physischen Anthropogeographie. Zeitschrift fur Geopolitik, I, Heft 5 (May, 1925).

Philip, G., and Finch, V. C. Appleton's Standard School Atlas. New York. D. Appleton-Century Co., 1932

Spoehr, H. A. Photosynthesis. New York: The Chemical Catalog Co., 1926.

Taylor, G. Australia. New York: E. P. Dutton & Co., 1943.

Thompson, W. S. Danger Spots in World Population. New York: Alfred A. Knopf, 1930

Thompson, W. S. Plenty of People. Lancaster: The Jaques Cattell Press, 1944

Thompson, W. S. Population Problems. New York: McGraw-Hill Book Co., 1935.

Tung, S. F. The Food Supply and Population of the World. Unpublished thesis, Cornell University, 1924.

U.S. Department of Agriculture. Climate and Man: Yearbook of Agriculture, 1941. Washington, D.C., 1941.

U.S. Department of Agriculture. The National Food Situation. Washington, D.C., 1942. Bureau of Agricultural Economics, Mimeographed Report (October, 1942).

U.S. Department of Agriculture. Soils and Men. Yearbook of Agriculture, 1938. Washington, D.C., 1938.

U.S. Department of Agriculture. Yearbook of Agriculture, 1936. Washington, D.C., 1936.

Van Loon, H. W. Van Loon's Geography: The Story of the World. Garden City. Garden City Publishing Co., 1940

Weir, W. W. Soil Productivity As Affected by Crop Rotation. Washington, D.C., 1926. U.S. Department of Agriculture, Farmers' Bulletin No. 1475 (May, 1926).

Whitbeck, R. H., and Finch, V. C. Economic Geography. New York: McGraw-Hill Book Co., 1935.

Whitbeck, R. H., and Williams, F. E., and Christians, W. F. Economic Geography of South America. New York: McGraw-Hill Book Co., 1940.

Woodbury, R. M. Food Consumption and Dietary Surveys in the Americas. Montreal: International Labor Office, 1942.

Wright, Q. A Study of War. Vol. I. Chicago: University of Chicago Press, 1942.

Index

Aberastury, M. F., 83
Acreage, adapted to crops, 48, 49, 50
  land and food crops, 20
  possible expansion, 49
Adams, G., 82
Agricultural colleges, expansion, 77
Air, composition, 35
  warm, rises, 33
Alfalfa, improvement, 58
American invasion, 77
Amusement, low priority, 1
Animal foods, consumption, 13, 17
    by lower third, 70
  difficult to increase, 71
  half of United States food dollar, 17
  high priced, 17
  importance, 6
  production, 10
  quarter of food eaten, 17
  see Eggs; Fish; Meat
  sources limited, 17
  trade, 10, 11
Atmospheric blanket, absorbs sun's rays, 32
  earth has two, 32
  like glass house, 33
  pressure of, 23
  rotates with earth, 32
  temperature of, 33
  thickness, 32
  weight of, 23

Bacon, L. B., 81
Baker, O. E., 49, 81, 82
Barley, importance, 6, 11
Beans, lima, 57
Beef, *see* Cattle
Beets, sugar, development, 57
Bengston, N. A., 81
Bennett, M. K., 82
Bread, black *vs* white, 2
Broadley, H., 82
Buck, J. L., preface, 82
Buckman, H. O., preface, 83
Butter and cheese, importance, 17

Calories *vs.* pounds dry matter, 81
Carbon, large part plants, 36
  small part air, 36
Carbon dioxide, amount used, 36
  area with adequate, 48
  area with adequate, combined with other factors, 48
  artificial application, 36
  equalized in air, 36
  importance, 35, 36
  source of, 36
  supply uniform, 36
Carnivorous animals, inedible, 16
Cattle, importance, 7, 16
  triple function, 60
Chang, C. C., 82
Chao, P. C., preface

INDEX

- Chatfield, C., 82
- Cheese and butter, importance, 17
- Chickens, importance, 8, 16
- Chocolate, 58
- Christians, W. F., 83
- Citrus fruit, recent expansion, 57
- Clark, C., 82
- Clothing, low priority, 1
- Consumption, amount daily, 15
  - cost of living studies, 13, 14
    - compared with production studies, 13
    - grain, plant and animal, 13
  - effect of income, 17
  - importance, of various foods, 16
    - various parts of plant, 16
  - per capita, 11
  - production studies, 11, 12, 13
    - animal, 13
    - grains and plant, 13, 14, 15
  - purposes, 14
  - varies with climate, size, etc., 12, 15
- Corn, hybrid, effect on yields, 58
  - importance, 6, 7, 11
  - spread over the world, 57
  - trade, 11
- Cost of living studies, compared with food production, 13
- Cows, discarded dairy, source of beef, 7
- Crawford, W., 82
- Cushing, S. W., 82

- Danger spot, Europe not Asia, 75
- Davis, D. H., 82
- De Candolle, A., 82
- Deficit and surplus areas, 74
- DeGraff, H. F., preface
- Deltas, size of, 43
- Deserts, fertility of, 45
- Diseases, plants and animals, 61
- Double cropping, extensive in Asia, 59
- Down-trodden third, ways to help, 70
- Drainage, costs, 30
  - importance, possibilities, 31
- Drained land, source of food, 31
- Dykes, Holland, 30

- Earth, age of, 37
  - size of, 37
- Earth's crust, how changed, 38
  - soil, 42
  - surface, thickness of, 42
- East, E. M., 82
- Education, low priority, 1
- Eggs, amount consumed, 15
  - importance, 6
- Equality not established by peaceful methods, 76
- Equalization, food, 69, 70
- Erosion, alters land forms, 38
  - beneficial and harmful, 38
  - defined, 26
- Eskimo, food consumption, 12
- Evaporation, effect of temperature, 25
- Experiment stations, expansion of, 77
- Exports, 10, 77

- Famines, none when livestock abundant, 73
- Feed for livestock, grain, 8
- Fertilizer, commercial, 52, 54
- Finch, V. C., 82, 83
- Fish, amount consumed, 15
  - areas, 63, 64
  - importance, 5
  - live on plants, 63
- Floodplains, 43
- Fruit, amount consumed, 15
  - and vegetables, production, trade, 5, 11
- Fuente, F., 83

- Goats, importance, 8
- Goode, J. P., 82
- Grain, acres per person, 68
  - amount consumed, 15
  - amount fed, 8, 9
  - importance, 6
  - production, 5, 68
  - *see* Seeds, mature
  - trade, most of, 11
- Grimm, alfalfa, 58

- Hannay, A. M., 82
- Hartwig, H. B., preface

INDEX

Heat, artificial, cost, 31
  from sun, 31, 32
  necessary for growth, 31
High cost of living, 77
Hill lands, described, 39
Hills, area, 41
Hitler, 76, 77
Horse *vs.* mechanical power, 56
Housing, low priority, 1
Huntington, E., 82

Ill-fed third, 2
Immigration, possibilities, 49, 50
  restrictions, 77
  to agricultural areas slowing down, 49
  to New World, 2
Imports, food, Europe largest, 10
Income, effect on consumption, 17
Indian Year Book, 82
International Institute of Agriculture, 82
Irrigation, area, 28
  costs, 29, 30
  Himalayas, 29
  important, 31
  most in Asia, 28, 29
  no shortage land, 28
  possibilities, 28
  shortage of water, 29
  source of food, 31
  United States, 29
Israelsen, O. W., 82
Iturraspe, J. E., 83

Juices, amount consumed, 15

Kaiser, 77
Kendrew, W. G., 82
Klages, K. H. W., 82

Labor, effect of larger amounts on production, 55
Land forms, best distribution in Europe, 41
  defined, 37
  unevenly distributed, 41
Lawrence in Arabia, 16
Lay of the land, importance, 22
  rain, 24
Leaching, defined, 26
  in grasslands, 15
  in tropics, 34
League of Nations, 82
Leaves, importance, 6
Lebensraum, 76, 78
Light, absorption of carbon dioxide, 35
  artificial, cost, 31
  does not limit food production, 35
  necessary for growth, 31
Livestock, a shock absorber, 73
  breeding for appearance, 60
  improvement slow, 60
Loess soils, wind-carried, 40, 41
Lyon, T. L., 83

Machinery, effect on production, 56, 57
  replaces horses, increases food, 56
Malthus, 2
Manure, animal, 52
  animal more important than human, 53
  green manure crops, 52, 54, 55
  human, 52
  human, increased use, 53
Meat, amount consumed, 15
  importance, 6
  production, 5
Mendel's law, 58
Migone, R. C., 83
Milk, amount consumed, 15
  amount produced, 5
  possibilities of expansion, 71
  produced everywhere, 7
  production on glacial plains, 41
  quart a day, 71
  related to pastures, 7
  uses, 16
Miller, E. C., 83
Moisture, *see* Water; Rainfall
Mordoff, R. A., preface
Morimoto, K., 83
Mountains, and rains, 24
  area, 41
  described, 39

INDEX

Mountains *(continued)*
  height, 37
Mussolini, Benito, 30

National Industrial Conference Board, 83
Nebuchadnezzar, 58
Nitrogen, 54

Oats, importance, 7
Ocean, depth of, 37
Oil seeds, importance, 7
Okies, 26
Olcott, M. T., 83
Organic matter, importance, 43

Paarlberg, D., preface
Penck, A., 49, 83
Philip, G., 83
Phosphate, 54
Photosynthesis, 20, 21
  and supply of carbon dioxide, 36
  inefficient, 35
Pigs, importance, 16
Plains, area, 41
  glacial, dairy production, 41
  importance, 39
  types of, 39
Planners and plans, no shortage, 17, 71
Plant, breeding, effects, 58
  foods, consumption, 13, 15
    importance, 6
    production and trade, 10
  growth, critical period, 26
  life of water, 63
  needs of, 21
Plateaus, area, 41
  defined, 38
Platt, F. L., preface
Polar regions, little rain or snow, 24
Pontine marshes, 30
Population, continental, 68
  control, 71
  danger spots, 75
  density, 67
  excess from Europe, 76
  irrigated crops, 28, 29
  possible expansion, 68, 69
  pressure, and war, 76
  pressure on food supply, 2, 8, 67
  response to food, 2
  supported at various continental standards, 69
Pork, importance, 8
Potatoes, world-wide, 57
Poultry, importance, 8
Priority, food *vs.* clothing, education, housing, 1
Production, amount, 5
  effect of fertilizer, 52, 55
  effect of labor, 55
  effect of machinery, 55, 56
  increasing acreage and yields, 19
  increasing on present acreage, 51
  plant, animal, 7
  proportion of continents adapted to food, 50

Rain and mountains, 24
Rainfall, adequate and inadequate, 26
  area with adequate, 48
  area with adequate, combined with other factors, 48
  area with reliable, 48
  area with reliable, combined with other factors, 48
  ideal, 26
  nature's free work, 24
  on earth's surface, 26
  seasonal needs, 26
Rationing food, 70
Redistribution of surplus food, 2
Regimentation leads to nationalism, 79
Religion influenced by food, 1
Rice, double and triple cropping, 59
  importance, 6, 7, 11
  polished, 15, 16
  trade, 11
Rocks and plant food, 21
Roots, importance, 6, 15
Run-off, effect of climate, 25
Rye, 7, 15

Sap, importance, 6, 15
Schloemer, F. C., 81

INDEX

Scoville, G. P., preface
Scudder, M., preface
Sea, food from, 63
  yields low, 64, 65
Seeds, immature, importance, 6
  mature, most of food, 6, 15
Sheep, importance, 8, 16
  parts eaten, 16
Shortage, food, 2
  likely to continue, 79
Social uplifters, 17
Soils, area with fertile, 46, 48
  area with fertile, combined with other factors, 48
  complex, 46
  forest, importance, 45
  formation of, 42, 44
  functions, three, 46
  insignificant, but most important part of earth, 42
  moved by water, 43
  organic matter, 43
  podzol, importance, 46
  quality difficult to measure, 46
  tropical, leached, 49
  tundra, importance, 45
  types, 44
  weathering, 42
Soybeans, expansion recent, 58
  pressed for oil, 16
Spoehr, H. A., 83
Standard of living, adjustment in Europe, 79
  and population, 68, 69
  Europe dependent on trade, 76
  high in Europe, 12
  ways to improve, 70
Starvation, 2, 12, 74
Stems, importance, 6, 15
Strawberry, 58
Struggle for existence, 1
Sugar, amount consumed, 15
  beets, 16
  beets, improved varieties, 57
  cane, 15, 16
  produced everywhere, 7
  production, 5
  trade, 11
Sun, rays and atmospheric blanket, 32
  size of, 31
  source of heat and light, 31
Sunlight, area with adequate, 48
  area with adequate, combined with other factors, 48
  required, 21

Taylor, G., 83
Temperature, area with favorable, 34, 48
  area with favorable, combined with other factors, 48
  causes of variation, 32, 33, 34
  effect on evaporation, 25
  effect on moisture in air, 23
  three belts, 34
Thompson, W. S., 83
Tomato, once thought poisonous, 57
Topography, area with favorable, 48
  area with favorable, combined with other factors, 48
  favorable, 42
  see Land forms; Plains, etc
Trade, between continents, 9
  between countries, 9
  grain most important, 11
  importance to Europe, 79
  within countries, 9
Trewartha, G. T., 82
Tropics, leached soils, 34
  much rain, 24
Tung, S. T., 83

United States Department of Agriculture, 83
Upgrading food habits, 17

Van Loon, H. W., 83
Van Royen, W., 81
Van Valkenburg, S., 82
Varieties, new, 57
Vegetables, amount consumed, 15
  and fruits, production and trade, 5,

War, cause of, 76
  effect on food supplies, 74

War (*continued*)
  frequency, 76
  luxury for rich, 75
Wartime food problems, 72
Water, amount needed, 25, 26
  content of foods, 11, 12
  covers three-fourths of earth, 63
  food from, 63
  loss through evaporation, run-off, drainage, 25
  necessary for growth, 21, 25
  present everywhere, 22
  transports soil, 43
Weir, W. W., 83
Wheat, basic food, 15
  importance, 6, 7, 11
  milled, 16
  trade, 11
Whitback, R. H., 83
Williams, F. E., 82, 83
Wind, monsoon, 24
  moves soil, 43, 44
  transports water, 23
Woodbury, R. M., 83
Wright, Q., 83

Yields, effect of hybrid corn, 58
  per acre, 51